PITTSBURGH GEOLOGICAL SOCIETY FIELDTRIP

MAY 6, 2000

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PITTSBURGH GEOLOGICAL SOCIETY FIELD TRIP - FIELD STOP DESCRIPTIONS

STOP 1

Our first stop is at an outcrop at the Commons area of the Morgantown Mall, near the Westover exit of I 79. We will see and hear about the Pittsburgh coal bed and nearby strata there, described by Nick Fedorko of the West Virginia Geological and Economic Survey in Table 1A by Fedorko (1998). Nick will give you other handout figures for this outcrop and lecture about it. Nick included this outcrop in his WVU M.S. thesis work of 1998, addressing paleosols. You are not allowed to touch this outcrop by the Mall security, with their fear of liability problems if someone becomes hurt there by falling rocks.

This outcrop exposes the Redstone limestone at the top, which displays karst features. Below this is a 3 foot mudstone bed, followed by the 8 feet thick Pittsburgh coal bed. Below this coal are claystone, mudstone, and shale. The Pittsburgh coal has been extensively mined in both West Virginia and Pennsylvania, mainly by underground mining. Older mines are the room-and-pillar type, and one such mine was exposed in this outcrop, but slumping has covered a tunnel. Although this coal bed has been a major economic resource in this region, it has come at the price of long term acid mine drainage (AMD) from above-drainage underground mines, and of land subsidence damage.

See Nick's handout showing figures and tables illustrating the paleosols he has studied here. Table 1A in this guide book is taken from Nick's thesis (Fedorko, 1998).

LITHOLOGY	UNIT THK	CUMULATIVE
Limestone, light gray, hard, fine grained, massive, semi-conchoidal fracture; occasional thin, (<0-3) discontinuous, argillaceous limestone partings; irregular, sharp, rolling base.	12-3	78-5
Mudstone, light gray, with limestone nodules throughout, unit poorly exposed, up to 6-0 thick or greater; may replace part of Pittsburgh roof shale and coals laterally.	3-0	75-5
Shale, dark gray to black, carbonaceous, very fissile, contact with above unit not well exposed.	0-8	74-9
(Top of roof sequence, 8-4 thick)		
Coal, bright banded, weathered, blocky.	1-1	73-8
Shale, black, carbonaceous, and interlaminated streaks of coal and bone, very hard, blocky.	3-3	70-5
Shale, medium gray, very fissile.	1-5	69-0
Coal, bright banded.	0-4	68-8
Shale, medium gray with dark gray carbonaceous streak at base.	0-5.5	68-2.5
Coal, bright banded.	0-3.5	67-11
Shale, dark gray, carbonaceous.	0-3.5	67-7.5
Coal, thin streak.	0-0.5	67-7
Shale, light gray, very fissile.	1-2	66-5
(top of main bench, 8-7 thick)		
Coal, bright banded, abundant vitrain.	2-5	64-0
shale, black, carbonaceous, coaly, parting.	0-0.5	63-11.5
Coal, as 2-5 bench above.	1-11	62-0.5
Shale, black, carbonaceous to coaly, parting.	0-0.5	62-0
Coal, as above, with occasional fusain bands.	4-2	57-10
B. Pittsburgh Coal El: 1096 (B.)		
Claystone, medium gray with dark gray streak 0-3 from top; occasional 0-0.5 diameter "framboidal" pyrite nodules and strings of nodules.	1-0	56-10
Mudstone, light gray, non-calcareous, with abundant limestone nodules throughout up to 0-8 across, poorly exposed, float indicates there may be a nodular limestone bed in this interval.	1-10	55-0
Shale, medium to dark gray, and possibly carbonaceous in top; poorly exposed.	0-5	54-7
Shale, light gray, with abundant siderite nodules along bedding and filling joints.	7-7	47-0
Siltstone, light gray, shaly, siderite nodules, with light gray-brown flint clay bed in base, sometimes nodular layer, sometimes laterally replacing much of the siltstone; lenticular.	1-4	45-8

STOP 1, TABLE 1A; Morgantown Mall Commons Outcrop,
fm. Fedorko (1998)

STOP 1: Upper Conemaugh Group and Lower Monongahela Group strata exposed on the north side of the Morgantown Mall complex, near Interstate 79 Exit 152, Morgantown, WV.

Stop Leader: Nick Fedorko

Introductory Note:

The following discussion was taken, with minor corrections, small changes, and additions, from a field trip guidebook entitled "*Paleoclimate Controls on Carboniferous Sedimentation and Cyclic Stratigraphy in the Appalachian Basin*". This trip was held prior to the 1992 Annual Meeting of the Geological Society of America in Cinncinnati, Ohio. The title page of that guidebook is included for reference. Authors of the discussion are: Nick Fedorko, Blaine Cecil, Cortland Eble, and William Grady. It should also be noted that since1992, the section from the base of the Redstone coal to the base of the sandstone below the Sewickley coal (fig. 1) has been excavated and removed to make room for the larger footprint of the Super Kmart store and its parking lot.

Background:

Approximately 18 m (58 ft) of Upper Conemaugh Group rocks and 32 m (106 ft) of lower Monongahela Group rocks are exposed in cuts made for the construction of the Morgantown Mall and upper commercial area (fig. 1). The section features five coal beds (some multi-benched) and an abundance of non-marine, lacustrine limestone beds. Starting at the eastern end of the exposure, several benches of the Little Pittsburgh coal bed are interbedded with shales, mudstones, and lacustrine carbonates. The Little Pittsburgh coal bed is of minor economic importance, but is persistent enough to serve as an important stratigraphic marker. Important to our discussions of climatic impact on the rock record is the development of the soil profile beneath the Pittsburgh coal bed. Here, where the coal facies is well-developed, the subjacent soil profile is very poorly-developed, thin and contains some carbonate in the form of nodules. Locations along I-79 to the south illustrate the effects of the "Pittsburgh coal climate" on pedogenesis of the substrate where the coal facies is poorly-developed or absent (figs. 2 and 3). A brief discussion of these sites will follow.

The Pittsburgh coal bed is extremely valuable to the coal mining industry of West Virginia, Pennsylvania and Ohio, exhibiting remarkable lateral persistence of thickness and quality (fig. 2). In 1999, West Virginia mining operations produced 165,972,090 tons of coal, 30,666,607 tons of which came from the Pittsburgh coal bed. This represents about 18.5% of the state's production, down from past years when as much as 25% of the total came from this bed. The exposure in this section is a pillar left from the long-abandoned underground mining operations in this area.

Petrography and Palynology of the Pittsburgh Coal Bed:

The Pittsburgh coal bed exposed in the Mall cut has an 2.6 m (8.6 ft) thick main coal of generally low ash-yield and moderate sulfur content (fig. 4). Including roof shales and rider coal beds the Pittsburgh is 5.2 m (17 ft) thick. At this location the main bench can be broken down into 6 diagnostic benches, two more than are present six miles to the northeast where the coal was extensively studied in a surface mine at the Greer estate (figs. 5 and 6). The basal bench (lower 0.3 m, 1 ft) is present across most of the areal extent of the Pittsburgh coal. It is very high in sulfur and moderate ash-yield, and has a tree fern dominant palynoflora with distinct calamite and cordaite contributions. This lower bench is interpreted to represent the pioneering plant community of the Pittsburgh swamp. The ash yield and sulfur contents indicate that these plants grew in a planar swamp with a significant influx of surface and ground water. Peat oxidation was minor and the preservation of plant debris was moderate. Above the basal bench, up to the parting at the 1.2 to 1.4 m (4 to 4.5 ft) level, the coal is very low ash and moderate sulfur content and petrographically shows two trends in swamp development. These trends of increased peat preservation, as shown by increased >50 micron vitrinite components, are reflected in the sulfur content and palynofloral succession, but not in ash yield. The first, terminated by a fusain parting, displays an upward increase in vitrinite content, especially >50 micron component, an increase in calamite and arboreous lycopsid spores, and increased sulfur content. A second similar trend is terminated by the bone coal parting at four feet. Increased vitrinite and >50 micron vitrinite, arboreous lycopsid and calamite spores suggest a slight increase in surface water depth as peat accumulation proceeded. The increased sulfur content probably represents increased introduction of sulfur into the swamp by surface or groundwater as water depth increased. The termination of these trends by fire and sediment deposition demonstrates a rapid and significant change in the water table. The fusain parting changes laterally into a bone coal parting and is present sporadically throughout the Pittsburgh coal areal extent. The four foot parting was extremely widespread and occurs throughout the Pittsburgh coal at approximately the same level in the bed (Cross, 1952).

Allocyclic factors other than climate doubtless contributed to the vast areal distribution of the Pittsburgh coal bed. However, the thickness and quality of the coal appears to be strongly climate-controlled. During the initial stages of accumulation of the Pittsburgh paleopeat annual rainfall, augmented with surface water flow, was sufficient to allow the development of a large planar swamp. During later stages of peat development the influential effects of rainwater vs. surface/groundwater on peat composition, which in-turn influenced ash yield, sulfur content and maceral composition, varied with location and time. Ash yield and sulfur content, as well as the degree of degradation of the peat plant debris, were greater to the west of the Morgantown area probably because of more frequent and extensive incursions of fresh surface and ground water into the peat swamp. In the Morgantown area layers of high ash, high sulfur peat alternate with low-ash, low-sulfur peat, as in the Greer estate coal column (figs. 5 and 6) and Morgantown Mall (fig. 4). To the east the Pittsburgh coal is thicker, lower in ash yield and sulfur content than in the Morgantown area, and appears to have been, except for the basal high ash and sulfur bench, more influenced by rainfall. The paleoclimate during accumulation of the Pittsburgh paleopeat was, therefore, wet enough to allow initial swamp development and to allow parts of the swamp to be maintained primarily on rainfall, but not wet enough to inhibit the regular influx of surface and groundwater into the swamp along the western margins.

Facies Changes and Paleopedology of the Pittsburgh Coal Bed:

Six sections of the lower Monongahela Group on or near I-79 along a 79 mile-long traverse from Morgantown, West Virginia south to near Burnsville, Braxton County, West Virginia (fig. 2) illustrate the change from coal and lacustrine limestone dominated sections (gray color, e.g. Morgantown Mall section) to sections dominated by fluvial sedimentation and well developed paleosols (red color, e.g. Dumpling Run and Burns Run sections) (fig. 3). These facies changes were first noted by Arkle (1959) and have been interpreted as traversing from the lacustrine-swamp (Arkle, 1959, 1974), or flood-basin/interdistributary bay portion of the depo-system (north) (Hoover, 1967; Donaldson, 1969, 1974) to an updip alluvial plain (south) (Hoover, 1967; Donaldson, 1969, Arkle, 1974). Red shales and red-mottled paleosols become common in the Dumpling Run and Burns Run sections, where the presence of free iron suggests vadose zone development and subaerial exposure. Features of the paleosols include destruction of primary sedimentary features by pedoturbation, mottling, calcareous pedotubules, rhizoconcretions, carbonate glaebules, petrocalcic horizons, and slickensided vertic structures. The Redstone Limestone of F. and W.G. Platt (1877) is the only carbonate bed present at Clarksburg that is laterally persistent beyond the Weston Section. This limestone at Dumpling Run and Burns Run sections however is more poorly developed than further north and is strongly overprinted by pedogenesis. The Clarksburg section is transitional between Weston and those further south, exhibiting more coarse clastics and fewer carbonate beds. The coal beds become thinner or absent along this southward trend, with paleosols being found in their stratigraphic position. Thicker and more numerous sandstone units replace the carbonate beds, exhibiting rapid lateral changes from channel fill forms to thin, planar beds interbedded with flood plain red, green, and gray shales and paleosols (fig. 3).

Exposures of the Pittsburgh coal bed and seatearth and correlative rocks at these six sites comprise a paleocatena of organic and mineral paleosols formed on a coeval landscape (fig. 7). Study of these sites yields further insight into the prevailing climate and topography before and during accumulation of the Pittsburgh paleopeat than is possible from study of the coal facies alone.

Compound pedogenesis is evident within each of the profiles resulting from changes in climatic wetness and rising water table levels. During the initial or "clastic swamp" phase, weak pedogenesis of the siliciclastic sediment (seatearth) occurred under predominately reducing conditions at Morgantown and Clarksburg, the topographically lowest sites resulting in weak development of gleyed B and BC horizons (fig. 7). The next phase or "peat mire" phase began with the rise of the water table to the soil surface and accumulation of peat, ending pedogenesis of the siliciclastic material. Trends in volume percentages of coal macerals document a bottom-to-top of bed increase in peat degradation. The peat mire plant community eventually was drowned and buried by sediment. Shorter-lived, less extensive peat mires, interspersed with episodes of sedimentation resulted in the interbedded, thin coal beds and shales of the overlying roof sequence. An estimated 56,000 years passed from the inception of pedogenesis in the siliciclastic sediment to burial of the roof sequence.

A prominent slickensided horizon and deeper profile development at the topographically higher Weston site indicate a longer "clastic swamp" phase compared to the Morgantown and Clarksburg sites (fig. 7). With rise in the water table, the peat mire eventually onlapped the

Weston site. Trends in volume percentages of coal macerals indicate an upward increase in peat degradation.

The topographically highest positions of the Dumpling Run and Burnsville sites resulted in genesis of: slickensided horizons (Bss and Bsst horizons, fig. 7), subsurface accumulation of iron oxide (Bv and Bgc horizons, fig. 7), strong soil structure, in-situ clay production and translocation (Bsst horizons, fig. 7) and redoximorphic concentrations and depletions, all consistent with a moist savanna climate with a mean annual rainfall of 900 to 1,200 mm (35 to 47 in) and a 5 to 7 month dry season. Evidence for a shift to a rainforest-savanna climate with a mean annual rainfall of 1,200 to 1,800 mm (47 to 71 in) and a 2 to 6 month long dry season includes: highly leached, kaolinitic A horizons in the Dumpling Run and Burns Run profiles, carbonaceous root traces in the underlying gleyed horizon in the Burns Run profile, and degradation of redoximorphic concentrations (fig. 7). Both sites remained well enough drained to preclude accumulation of peat. The Jim Beall profile, occupying a local topographic low, exhibits similar but less well developed features and is capped by thin, impure coal in response to increased wetness (fig. 7).

Formation of low organic-matter content A horizons capping the Weston, Dumpling Run, Burns Run, and Jim Beall profiles may correlate in time with the roof sequence to the north, probably correlating with a change back to a moist savanna climate. Burial of the profiles with calcareous-rich sediments and development of calcareous paleosols within the sediments indicate further reduction in climatic wetness to a dry savanna to semi-arid climate.

Discussions of Other Coals and Rocks:

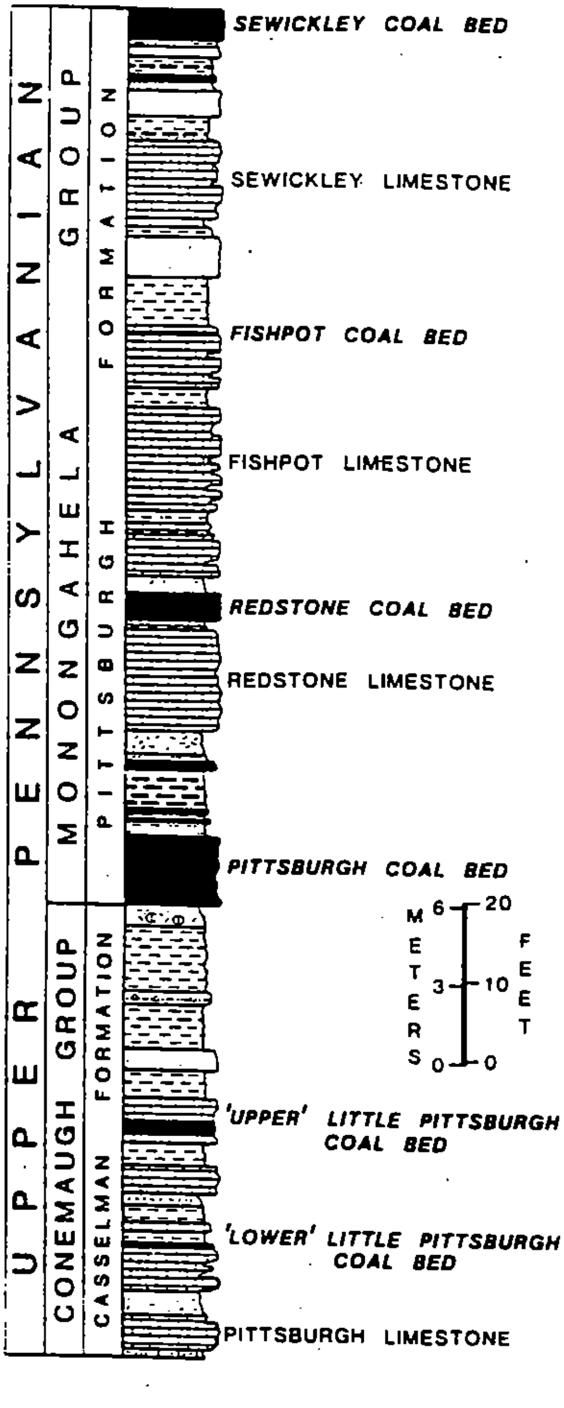
The Redstone coal exposed at the Mall stop shows a channel scour cut which eroded through the sediments deposited over the Redstone peat and partially into the peat (fig. 8). The eastern portion of the channel rises in the cut and the central portion is visible at road level, whereas the western side of the channel dips below road level. The coal was incrementally sampled at the center of the channel where the thickness was 0.6 m (1.95 ft) and as a full channel 21 m (70 ft) to the east where 0.7 m (2.3 ft) of coal remain (fig. 8). Thickness of the coal away from the channel in the high wall is approximately 1.2 m (4 ft). The lower 0.5 m (1.6 ft) of the coal displays typical ash yield and sulfur distributions for the Redstone coal in this area with high ash and sulfur in the basal increment and decreased ash and sulfur upward. The top 1.5 cm (0.6 in) of coal below the channel is high-ash bone coal. The coal immediately below the bone layer was moderate in ash yield, but extremely high in sulfur. The increased sulfur, probably in the form of pyrite, appears to have been emplaced after erosion of the channel, from solutions that originated in the channel fill. The channel is unique in that it was not filled by contemporaneous sediments; instead the bottom contains a 0.6 m (2 ft) thick paleosol with carbonate nodules. This unit pinches out toward the channel margin. Later channel fill sediments include alternating nonmarine limestones and shales.

A palynological analysis of a column of Redstone coal, located approximately 6 km (10 mi) to the north indicates that this coal bed, like the Pittsburgh, is also dominated by tree fern spores overall, but that palynoflora stratification can be detected. Typically, basal layers contain increased percentages of *Endosporites globiformis*, which was produced by *Chaloneria*, a shrubby, herbaceous lycopsid (Pigg and Rothwell, 1982). Increased percentages of gymnosperm pollen (mostly *Florinites, Vesicaspora* and *Pityosporites*) are also common in this part of the bed. In areas where the Redstone coal bed is thin, this miospore assemblage commonly occupies the entire bed thickness (Eble, 1985). In contrast, middle and upper layers of the Redstone coal bed typically show a change to a tree fern spore-dominant palynoflora (*Punctatisporites minutus*), although increased amounts of calamite spores (*Laevigatosporites* spp.), recognized by making an additional *Punctatisporites minutus* - free count, are observed (Grady and Eble, 1989). In addition, several small fern spore genera (e.g. *Leiotriletes* and *Triquitrites?*) are locally abundant at various levels in the bed (Habib, 1968; Eble, 1985). In a majority of its minable extent, the Redstone coal bed is low to moderate in ash yield (5 to 15 %) and moderate to high in sulfur content (2 to >5 %).

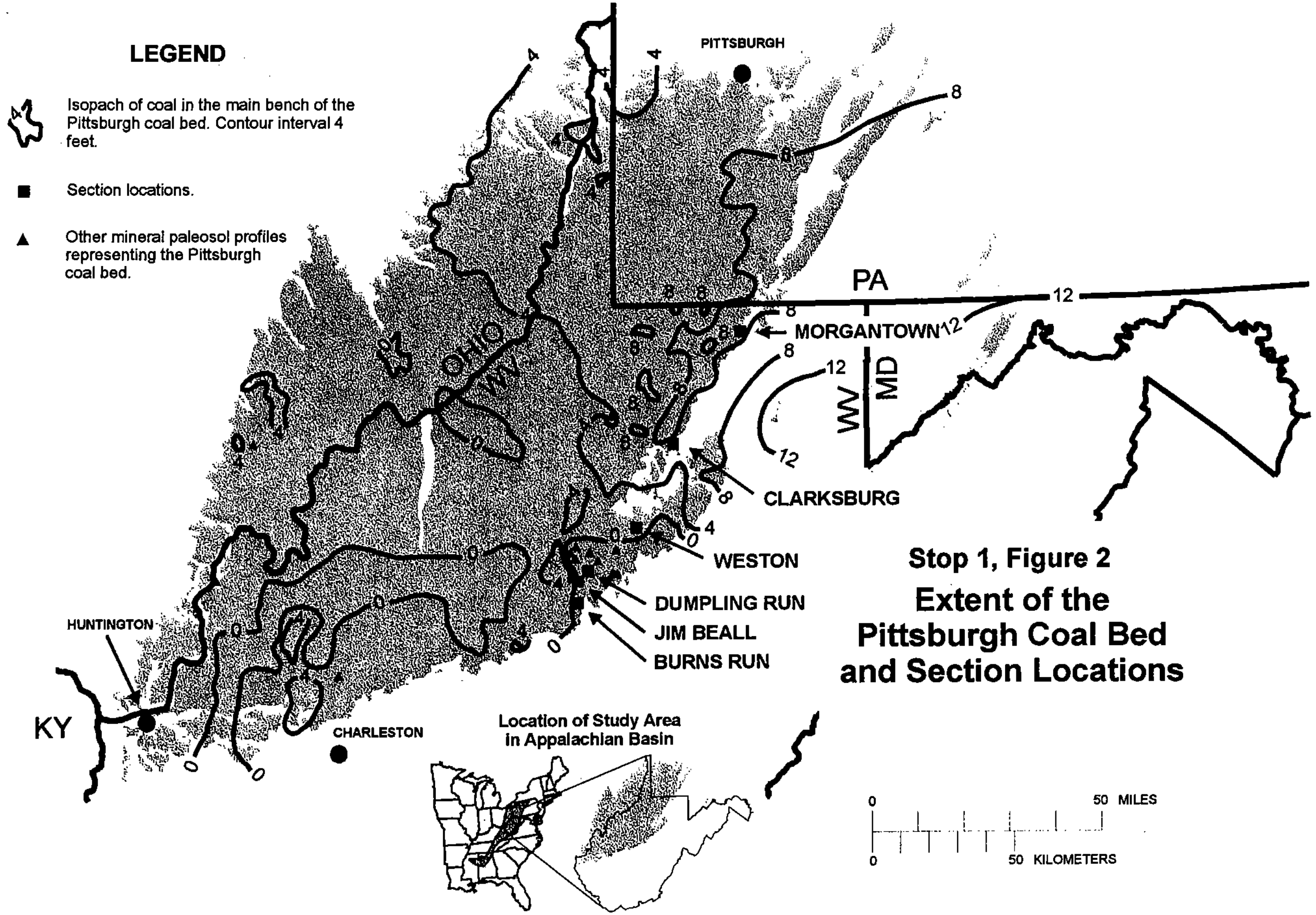
The Redstone Limestone, a well-developed non-marine, regionally extensive, lacustrine carbonate occurs above the Pittsburgh coal bed. Lacustrine limestones such as this one are most abundant in the Monongahela Group in the region encompassing northern West Virginia, southwest Pennsylvanian, and eastern Ohio. These carbonates are exclusively micrites, occurring in complexes interbedded with argillaceous limestones, calcareous mudstones, and calcareous and non-calcareous shales. The interbedded relationships of these carbonate complexes are well-illustrated by the exposures of the Fishpot and Sewickley Limestones at this stop (fig. 1). The Redstone Limestone generally occurs as a monolithic micrite, the result of deposition in an aerially extensive lake.

The Fishpot coal is only 2.5 cm (1 in) thick in this section and, with few exceptions, rarely exceeds 0.6 m (2 ft) in thickness. However, thin coal or carbonaceous shale can be found at this stratigraphic position at widely separated points throughout the Dunkard Basin.

The thickest sandstone in this section occurs in a clastic interval above the Fishpot coal bed. It is tabular, varying in thickness from 0.9 to 2.3 m (3 to 7.5 ft). Another clastic interval occurs above the Sewickley Limestone. Thin sandstone and shale beds are interbedded with the Sewickley coal bed here. The association of the Sewickley coal with fine to coarse clastic rocks is characteristic basin-wide. Lower coal benches or "splits" of the Sewickley are sometimes miscorrelated with the underlying Fishpot coal bed. The main minable bench of the Sewickley coal bed is not well-exposed at this location. The weathered blossom, 1.2 m (4 ft) thick, can be seen at the top of the section at the extreme western end of the cut. This bed has also been extensively mined underground in the Morgantown area.

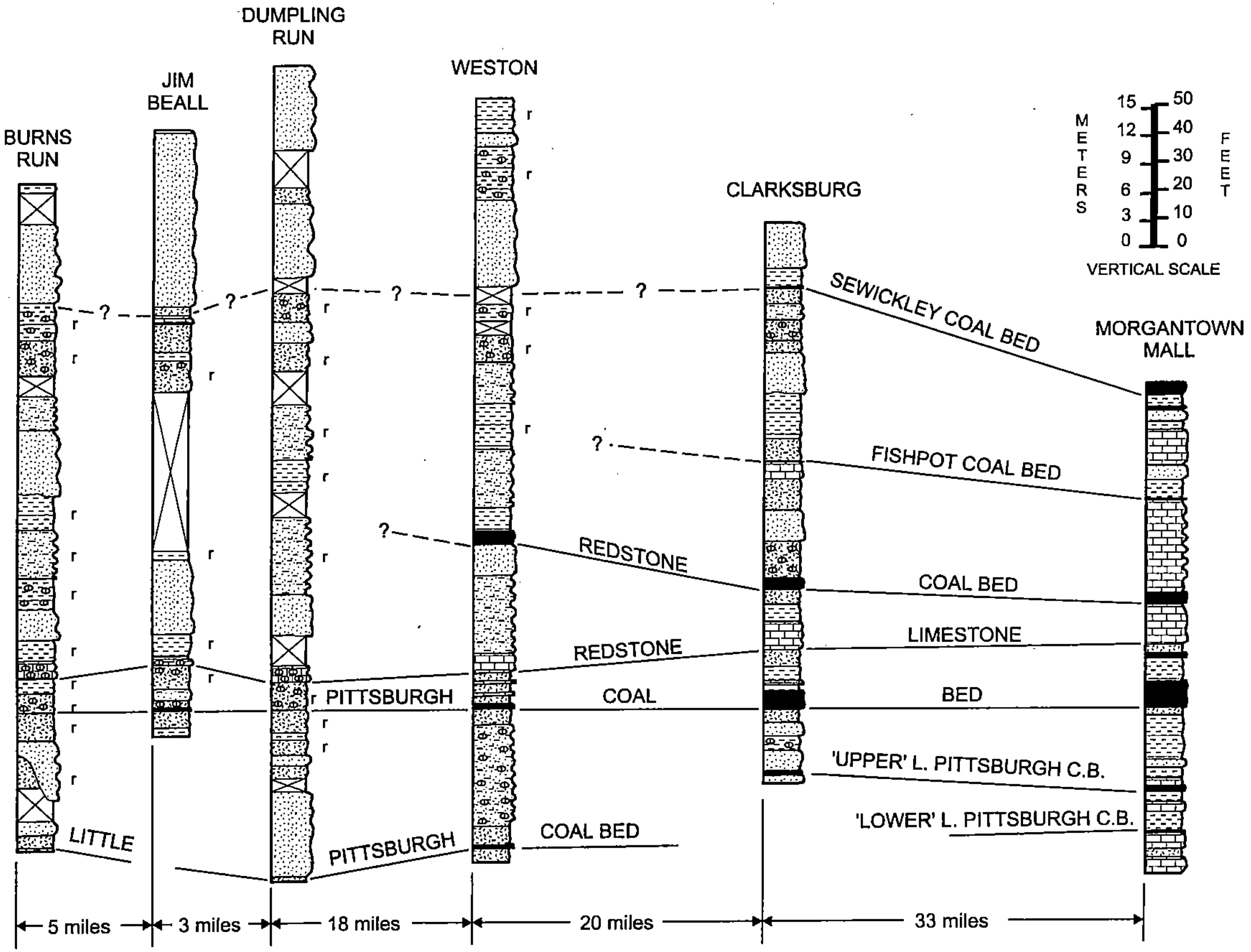


Stop 1. Figure 1 - Upper Conemaugh and lower Monongahela Group strata exposed along the north side of the Morgantown Mall complex.



Stop 1, Figure 2

Extent of the Pittsburgh Coal Bed and Section Locations

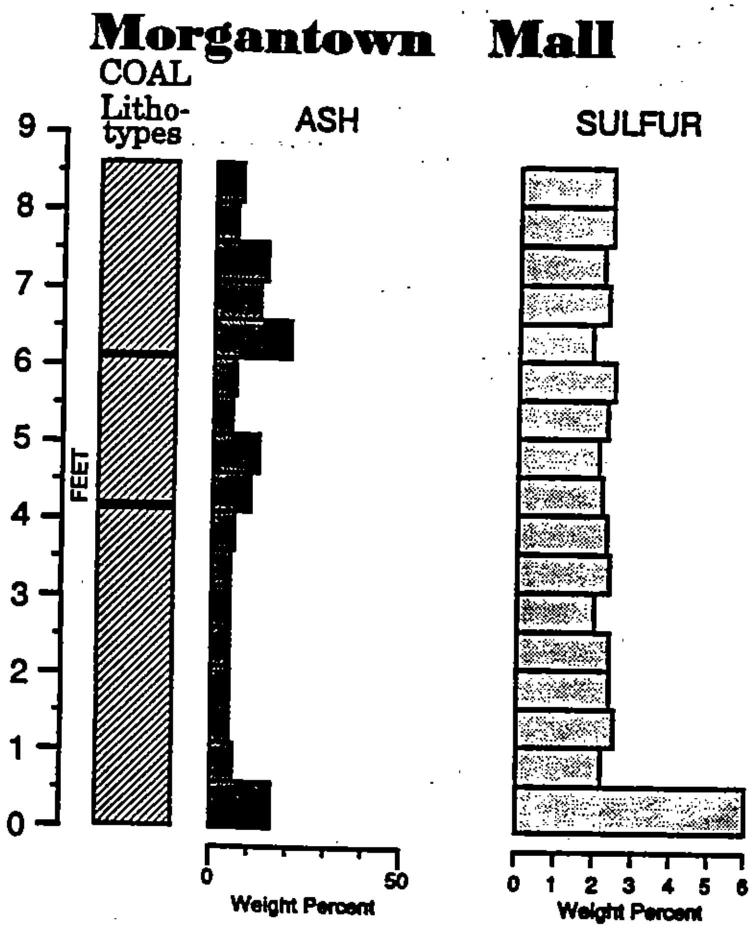


Stop 1, Figure 3 - Stratigraphic sections of the six Pittsburgh coal paleosol sites along I79 showing the facies changes and the thinning and ultimate loss of the Pittsburgh coal bed going from north to south. See Figure 2 for section locations. See the accompanying page for an explanation of symbols used on this figure.

LEGEND FOR SYMBOLS USED IN TEXT ILLUSTRATIONS

- ■ COAL
- ░ SANDSTONE
- ▤ SILTSTONE
- ▥ INTERBEDDED SANDSTONE AND SHALE
- ▭ SHALE
- ▨ MUDSTONE OR CLAYSTONE
- ▬ CARBONACEOUS SHALE OR BONE
- ▦ LIMESTONE
- ☒ COVERED INTERVAL

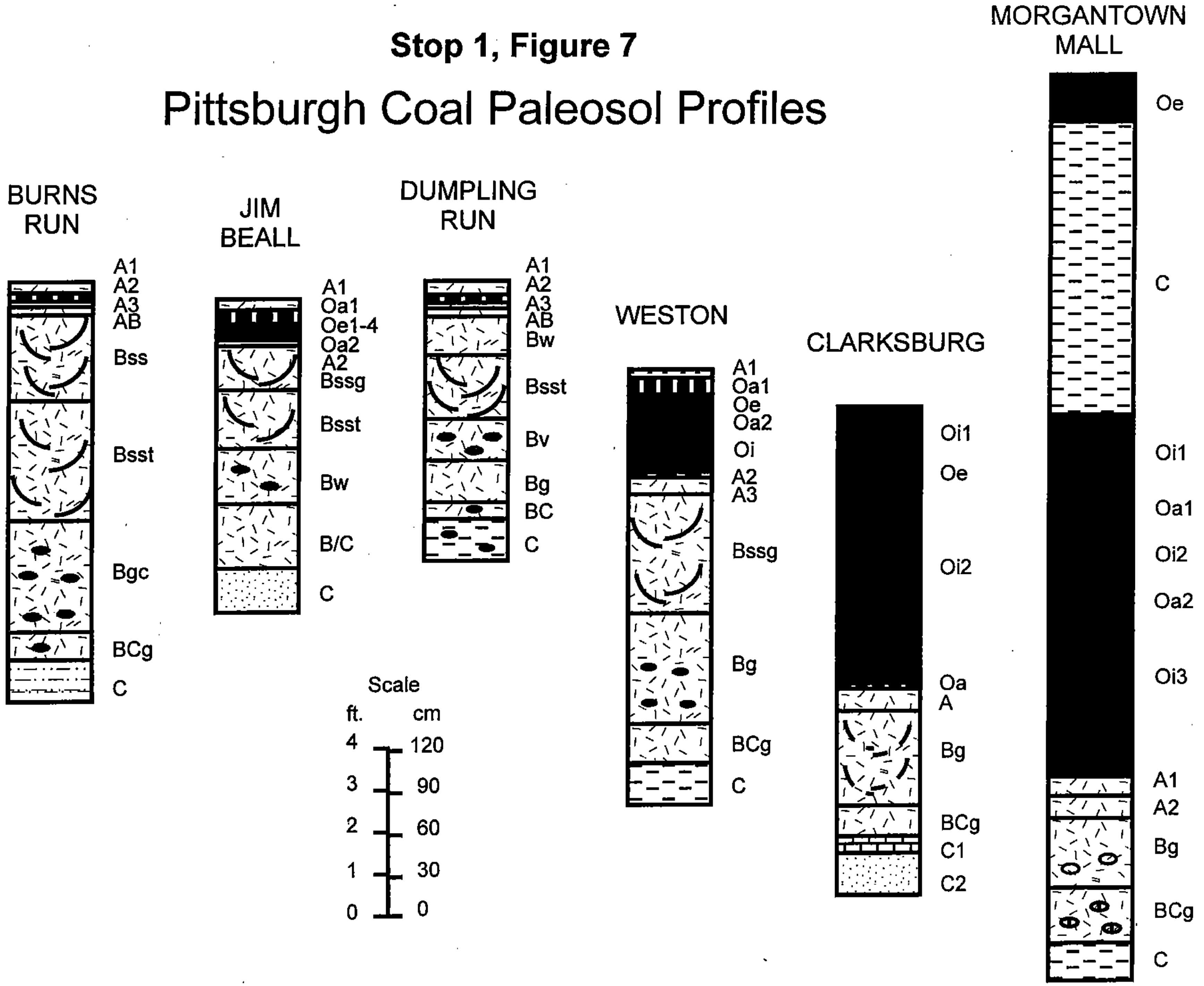
- ⦶ LIMESTONE NODULES OR CONCRETIONS
- ʃʃʃʃʃʃʃʃ ROOT IMPRESSIONS
- ⌇ BIOTURBATION
- 🐚 MARINE FOSSILS
- @ BRACHISH FOSSILS
- ● FRESHWATER FOSSILS
- 🌿 PLANT FOSSILS
- ∘∘∘ QUARTZ PEBBLES
- ⋕ FLINT CLAY
- S SIDERITE BANDS OR NODULES
- R RED OR MOTTLED RED
- P PALEOSOL



Stop 1, Figure 4 - Ash yield and sulfur distribution in the Pittsburgh coal bed exposed at the Morgantown Mall.

Stop 1, Figure 7

Pittsburgh Coal Paleosol Profiles



STOP 2

Our second stop is at the Omega mine along the Grafton Road (Route 119). This above-drainage room-and-pillar underground mine is within the Upper Freeport coal bed, which dips 11° to the northwest. The mine covers 170 acres. The 26 acre northern portion of it is shown in Stop 2 Figures 1 and 2. This mine was permitted over the objections of local environmentalists, and mining occurred from 1982 to 1989. Second mining (pillar robbing) has occurred in about 70 % of this mine, with some subsequent subsidence. After abandonment in 1989 the mine flooded from the downdip (northwest) end upwards, which caused new AMD springs to flow from the east-facing ridge flank near the coal crop line; these springs polluted nearby Cobun Creek which in turn polluted Morgantown's winter and spring seasonal water supply, the Cobun Creek reservoir, dropping the pH from about 6-7 to 5-6 and greatly increasing the sulfate concentration. What environmentalists had feared had happened. Information about the Omega mine was supplied by employees of the West Virginia Division of Environmental Protection (DEP), an environmental geologist, and Gray, et al. (1998).

Omega Mining Company then declared bankrupsey after being stuck with the AMD treatment costs, and their insurance companies had to be sued to pay off about $1,000,000 to cover that. A few years later that money was used up, but the mine kept producing AMD. At this point, in the early 1990's, the West Virginia DEP took over the AMD treatment expense. DEP set aside about $1,300,000, which was matched by an additional $1,000,000 contributed collectively by industry (Allegheny Power, Anker Energy Corp., Consol, Inc., and the Electric Power Research Institute) and by the federal Office of Surface Mining Reclamation and Enforcement (OSM). Annual average AMD treatment costs (labor and materials) are about $300,000 per year. In addition to this there have been capital expenses of roughly $2,500,000. These involved drilling 3 lateral boreholes in the early 1990's to drain water from the low (downdip) northern 26 acre mine end to the west-facing ridge side near Owles Creek for collection and treatment; for drilling about 215 vertical boreholes for geotechnical evaluation and mine grouting in 1998; and for injections of a grout mixture of flyash and fluidized bed combustion byproducts into the low northern mine end in an attempt to stop the mine acid generation. Since grouting occurred, new AMD springs emerged in early 1999 on the east ridge side, with severely contaminated AMD, which again polluted Cobun Creek.

The DEP now collects all AMD from both sides of the ridge and treats it with ammonia and hydrogen peroxide. Yellowboy sludge is transported from nearby sedimentation ponds to disposal sites at old surface coal mines. The AMD drainage rate varies greatly with seasons and weather; for example, it was only 120 gpm on 3/14/99 but was 22,848 gpm on 5/17/99. The AMD before treatment varies in water quality, and recently (on 6/14/99) had a pH of 2.5, a total iron concentration of 748 mg/L, an acidity of 2,520 mg/L as $CaCO_3$, and a sulfate concentration of 2,410 mg/L. It is still not apparent if the mine remediation measures have improved the AMD (with reduced flow rate and better quality). Other drift mines in similar AMD producing coal beds have been known to produce acid waters for generations.

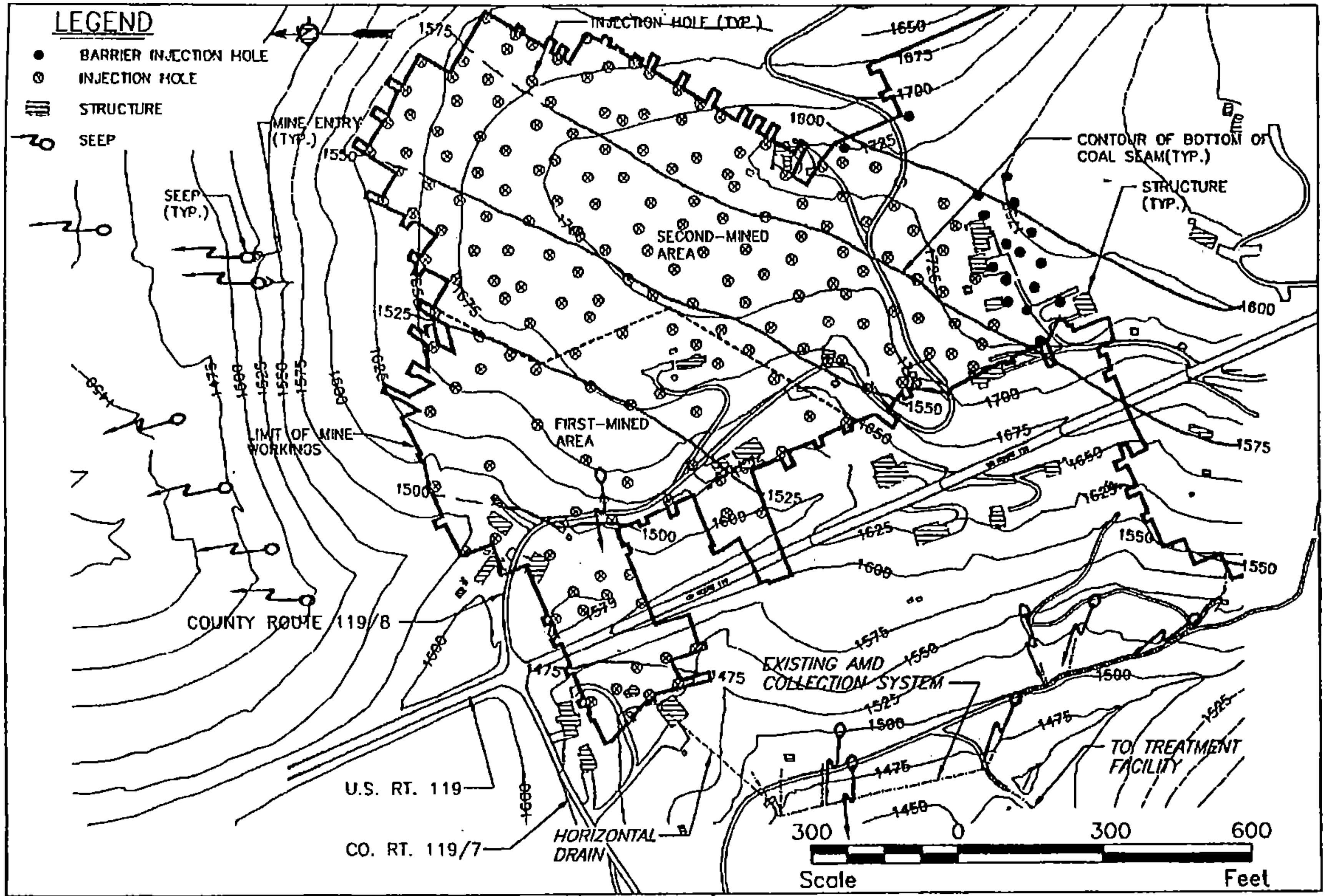
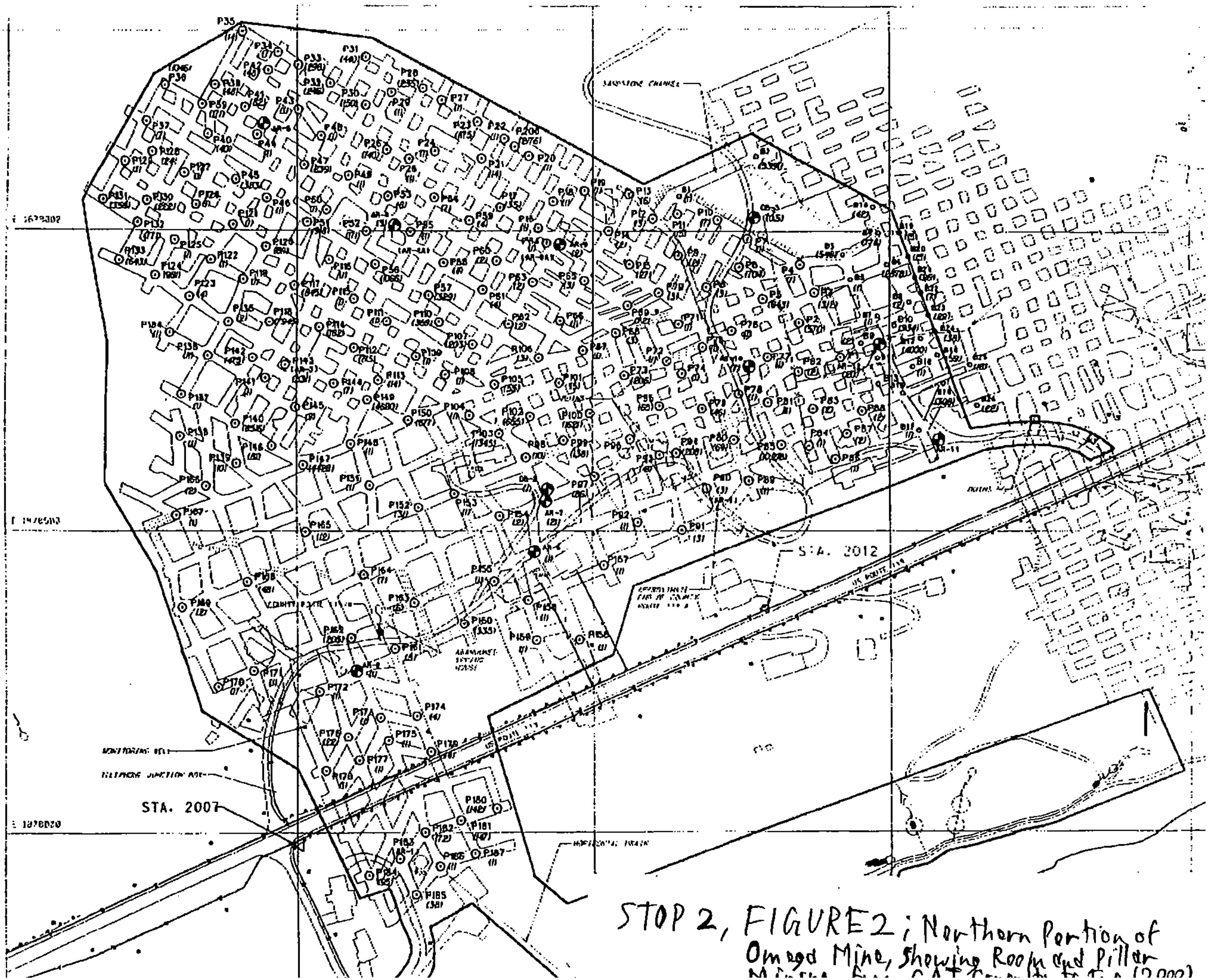


Figure 3. Omego Mine Complex – Injection Plan

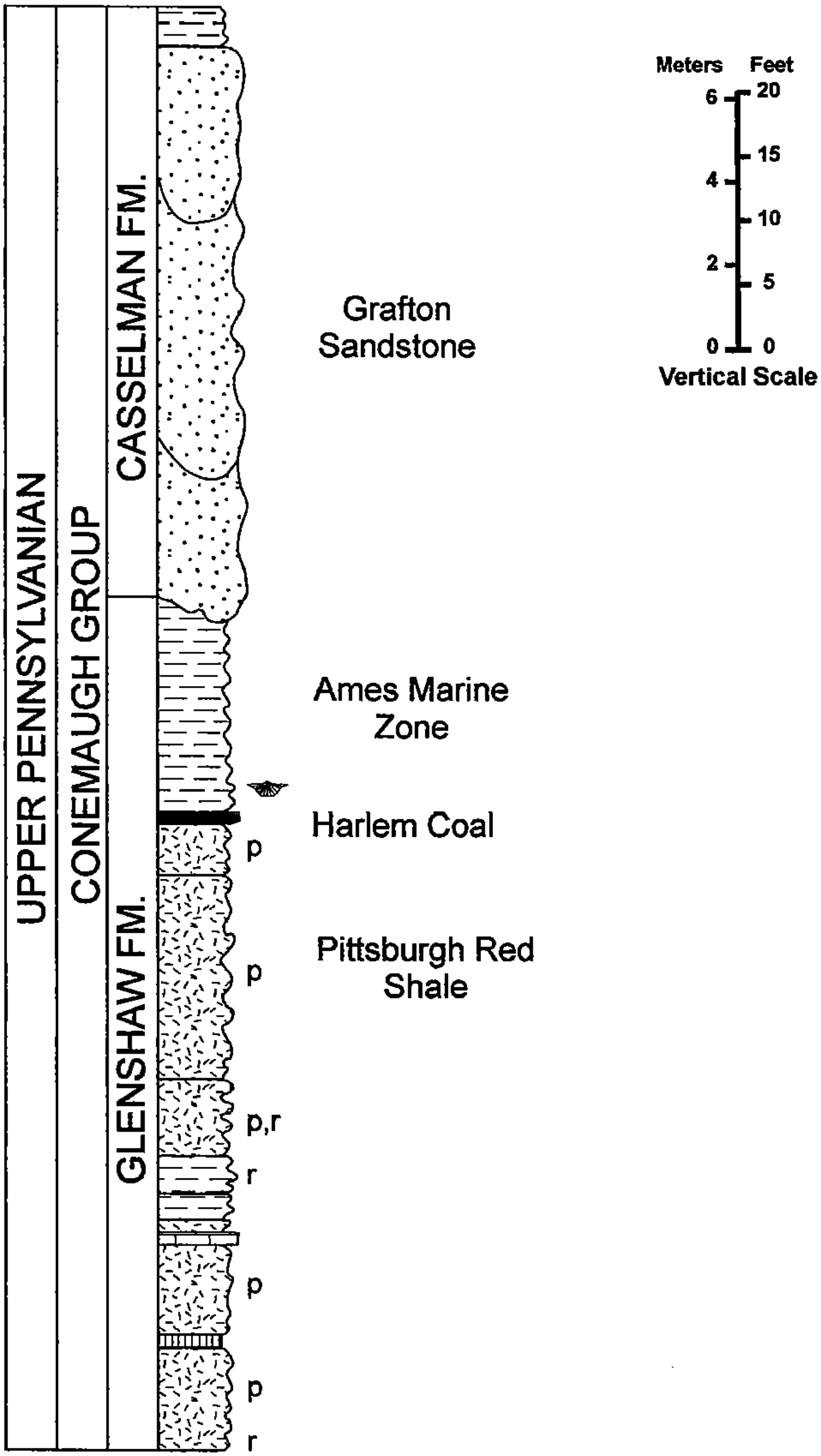
STOP 2, FIGURE 1; Northern Portion of Omega Underground Mine, after Gray, et al. (1998).



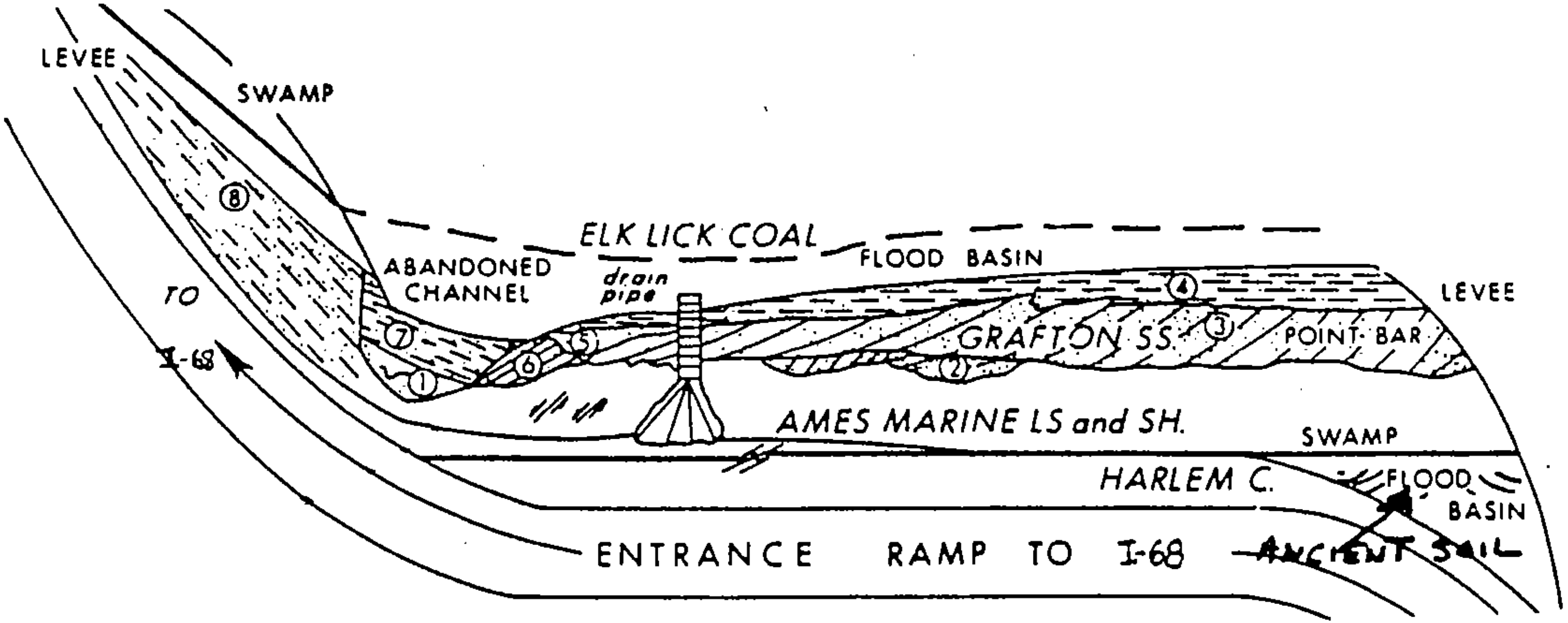
STOP 2, FIGURE 2; Northern Portion of Omega Mine, Showing Room and Pillar

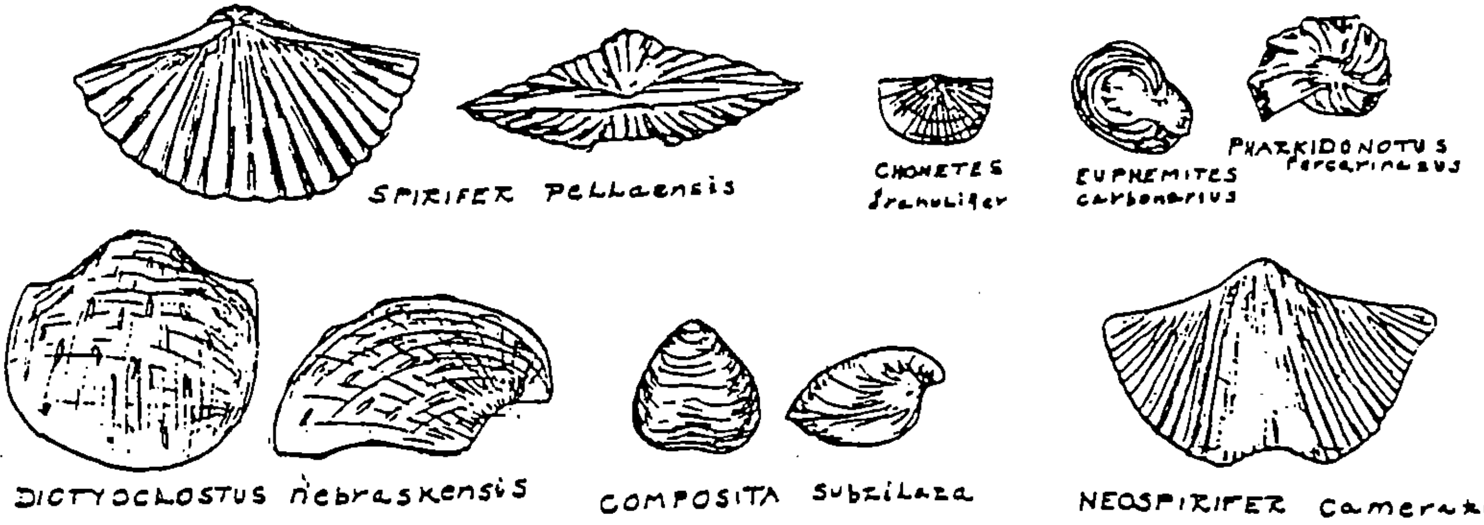
STOP 3

Our third stop is at an outcrop on the Sabraton entrance to I 68 going east. Here exposed is the Ames Limestone, a marine shaly limestone containing an underlying paleosol that Nick Fedorko will explain and has extra handouts for. This limestone has abundant small invertebrate fossils, especially brachiopods and pelecypods. Hopefully you'll find some with a little searching. See Figure 1A for Stop 3 for pictures which should help you identify fossils you find.



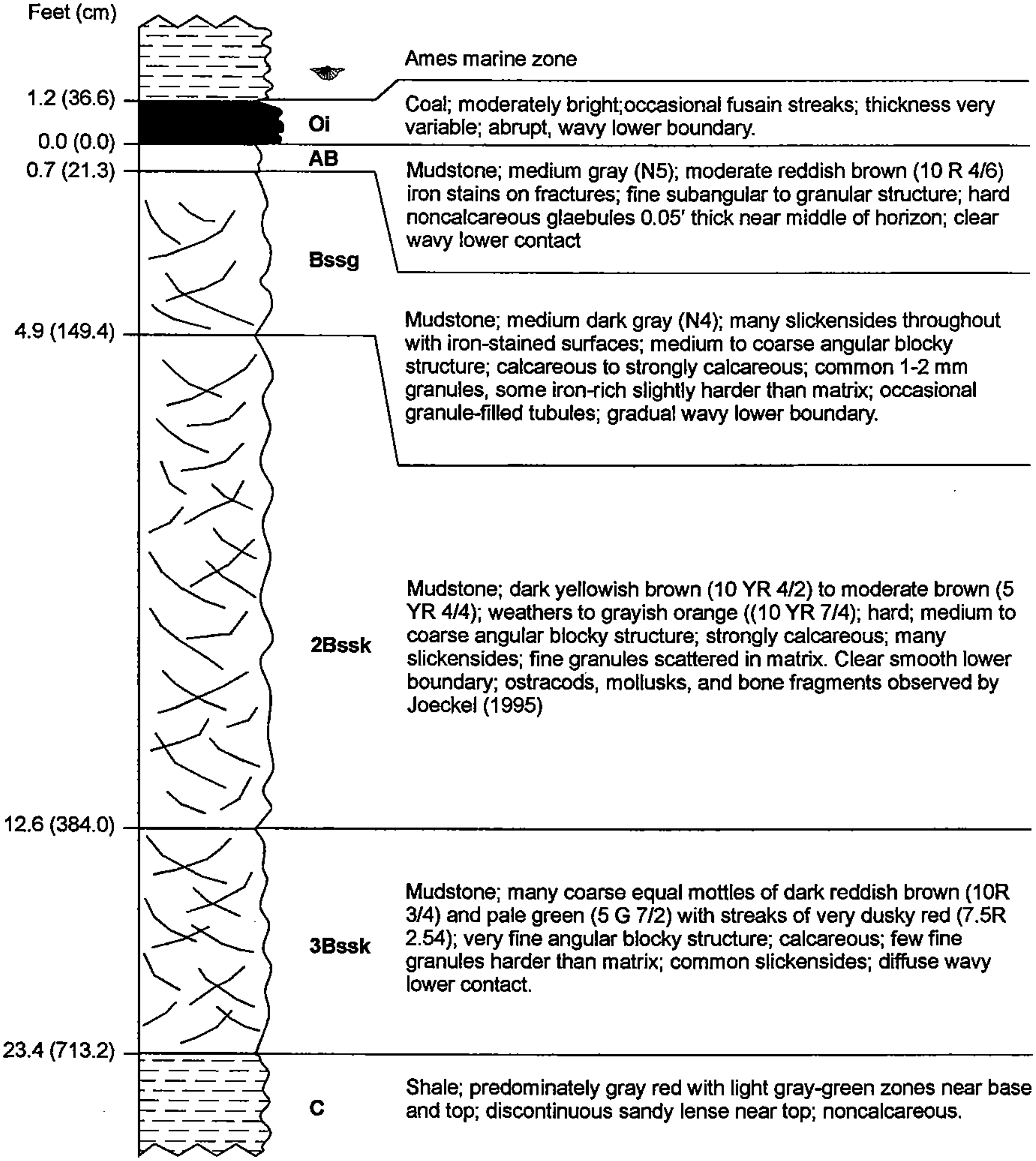
Stop 3, Figure 1- Conemaugh Group strata exposed along the east-bound entrance ramp to I-68 at Sabraton, West Virginia





Some marine invertebrate fossils from the Ames shales and limestones.

STOP 3. FIGURE 1A; after Geology 2 Field Trip Guidebook, by Donaldson (1994



Ames marine zone

Coal; moderately bright;occasional fusain streaks; thickness very variable; abrupt, wavy lower boundary.

Mudstone; medium gray (N5); moderate reddish brown (10 R 4/6) iron stains on fractures; fine subangular to granular structure; hard noncalcareous glaebules 0.05′ thick near middle of horizon; clear wavy lower contact

Mudstone; medium dark gray (N4); many slickensides throughout with iron-stained surfaces; medium to coarse angular blocky structure; calcareous to strongly calcareous; common 1-2 mm granules, some iron-rich slightly harder than matrix; occasional granule-filled tubules; gradual wavy lower boundary.

Mudstone; dark yellowish brown (10 YR 4/2) to moderate brown (5 YR 4/4); weathers to grayish orange ((10 YR 7/4); hard; medium to coarse angular blocky structure; strongly calcareous; many slickensides; fine granules scattered in matrix. Clear smooth lower boundary; ostracods, mollusks, and bone fragments observed by Joeckel (1995)

Mudstone; many coarse equal mottles of dark reddish brown (10R 3/4) and pale green (5 G 7/2) with streaks of very dusky red (7.5R 2.54); very fine angular blocky structure; calcareous; few fine granules harder than matrix; common slickensides; diffuse wavy lower contact.

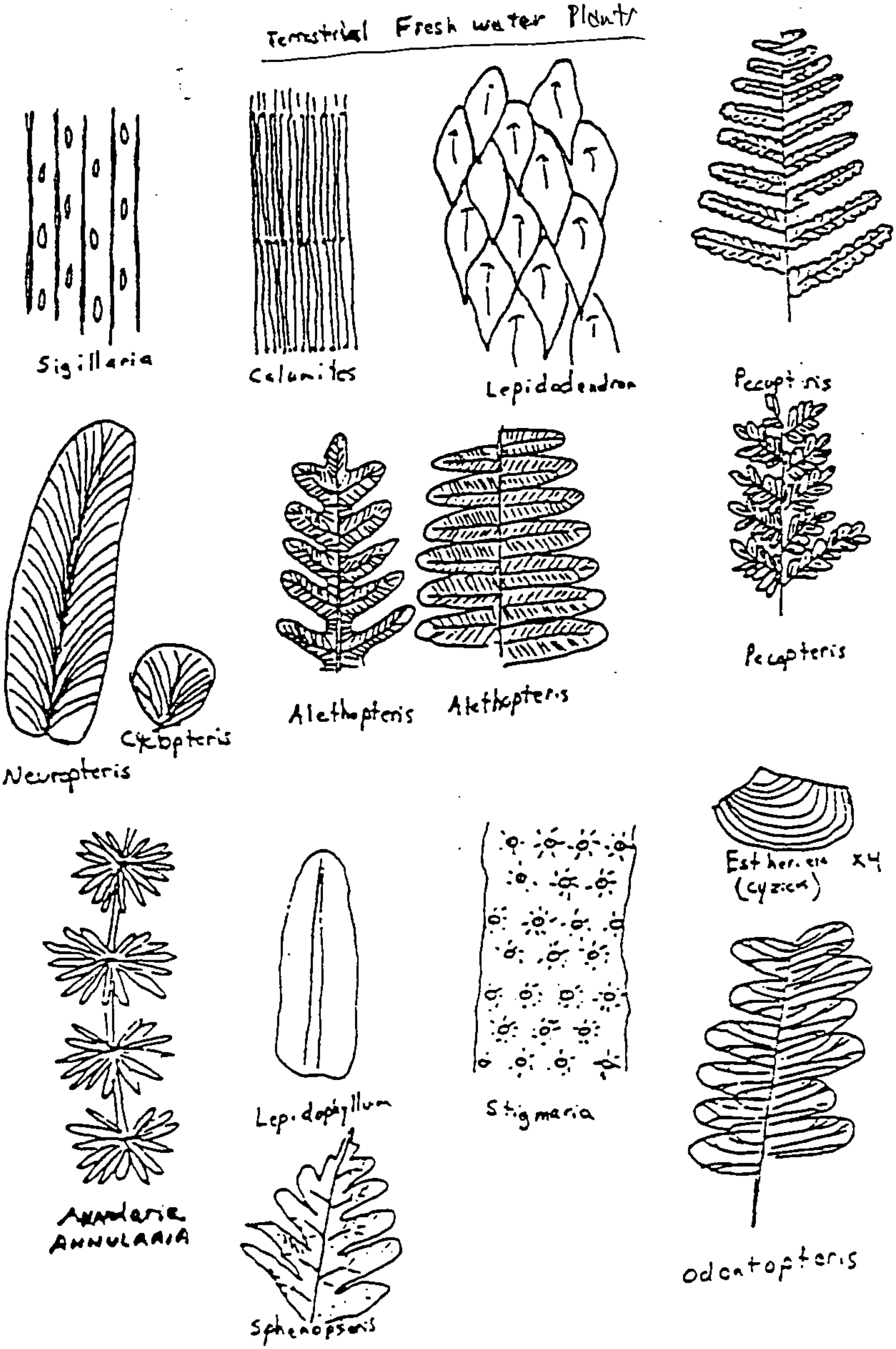
Shale; predominately gray red with light gray-green zones near base and top; discontinuous sandy lense near top; noncalcareous.

Stop 3, Figure 2 - Description of the paleosol beneath the Ames marine zone exposed along the east-bound entrance ramp to I-68 in Sabraton, West Virginia.

STOP 4

Our fourth stop is at an outcrop of the Upper Freeport coal bed and associated shale beds, about one-half of the way up Chestnut Ridge mountain along the east-bound lanes of I 68. This is the same coal bed that the Omega mine is in. Besides producing AMD from above-drainage underground mines, this coal bed produces AMD from surface coal mines (reclaimed or not) that have sandstone overburden rock in contact with the coal; however, the same coal bed produces alkaline drainage in surface mines where the contacting overburden rock is shale (diPretoro and Rauch, 1987).

If you look carefully you will find fossil plant fragments within chips or plates of shale derived from shale beds near the coal bed. The best places to look are away from "footprints" of past field trip persons. See Figure 1 for Stop 4 for pictures of common Pennsylvanian fossil plants, to help identify any fossils you find.

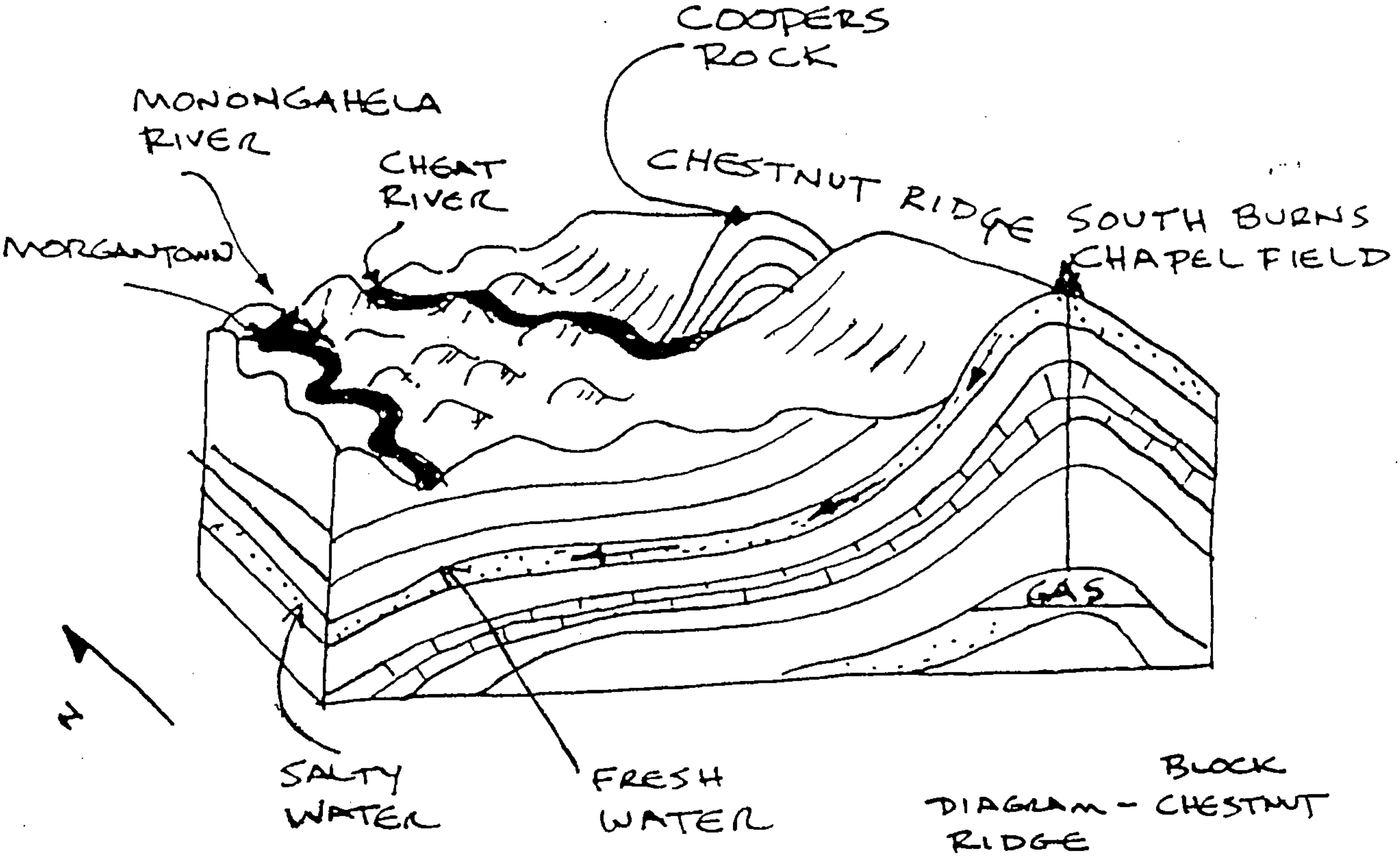


STOP 4, FIGURE 1; Pennsylvanian Freshwater Plant Fossils From Donaldson (1994).

STOP 5

Our fifth stop is at Coopers Rock State Park, where you can have a restroom break and a lunch stop. This park is on top of Chestnut Ridge and the Chestnut Ridge anticline. See Figure 1A for Stop 5, showing a sketch of the geologic setting here. This mountain is called Laurel Ridge in southwestern Pennsylvania. It exists because of the hard and massive Pottsville sandstone which acts as a protective cap rock. This rock is exposed at the Coopers Rock lookout at the cliff face there. From this spot you can look down to the Cheat River, some 1,200 feet below in a gorge carved out be this river. The Pottsville sandstone locally serves as an excellent aquifer for water supplies near the ground surface, and also as a prominent petroleum reservoir at depth. See Lee Avary's description and Figures 1 to 6, which describe the forest controversy here as well as nearby producing petroleum fields associated with this anticline. Lee, who is Head of the Oil and Gas Section of the West Virginia Geological and Economic Survey, will be the main speaker for stop 5.

If time allows, a subgroup of us will trek about 6,000 feet over to Rock City, an area of wide vertical cracks between giant rectangular boulders of the Pottsville sandstone. This site is very similar to the Rock City tourist site in the Allegheny Mountains of north-central Pennsylvania.



STOP 5, FIGURE 1A; Sketch of Chestnut Ridge and Anticline, near Morgantown

Pittsburgh Geological Society Field Trip, May 6, 2000

Coopers Rock Stop-Oil and Gas

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Coopers Rock State Forest (CRSF) is located along the crest of the Chestnut Ridge anticline, straddling the border between Monongalia and Preston counties, West Virginia. The area north of Interstate 68 is leased on a long term basis to the West Virginia University Division of Forestry for their research efforts. The portion of the forest south of Interstate 68 is run by the West Virginia Division of Natural Resources as a State Forest. The forest, acquired by the State in 1936, consists of 12,713 acres; immediately across the Cheat River from Coopers Rocks is the 2,000 acre Snake Hill Wildlife Management Area (SHWMA).

For a number of years, the State of West Virginia had been interested in acquiring the property across the Cheat River. Known as the "viewshed", the property was privately held, and had enormous potential for residential development. Also, for many years, various oil and gas operators had been interested in acquiring the oil and gas rights under the State Forest. Drilling is not prohibited on state forest land in West Virginia, while it is prohibited on the surface of State Park properties. In 1995, ALAMCO approached the West Virginia Public Lands Corporation, which holds title to the oil and gas rights for CRSF (as well as other public lands in the State) with a proposal to purchase the viewshed property and exchange title to it for the oil and gas rights under CRSF. A public hearing was scheduled to gather public input on this proposal, but prior to the hearing, public outcry and concern caused ALAMCO to withdraw the offer. The public hearing was cancelled. Subsequently, the State Division of Natural Resources was able to purchase the viewshed property and create the Wildlife Management Area.

Chestnut Ridge anticline is the westernmost anticlinal structure in the high amplitude folds province of the Allegheny Plateau. Along Chestnut Ridge, both to the north and south of the public lands (CRSF and SHWMA), there are gas fields (Figure 1). These fields are included in the Fractured Middle Devonian Huntersville Chert and Lower Devonian Oriskany Sandstone play. Flaherty (1996) provides as overview of this play. The producing formations are the Huntersville Chert and Oriskany Sandstone (Figure 2). The large (about 150 producing wells) South Burns Chapel field is located to the south (Figure 1). It was originally developed in the 1960's mostly by Phillips Petroleum and Consolidated Gas Supply Corporation. In the 1980's, ALAMCO engaged in an in-fill drilling and field expansion program. In mid-1997, Columbia Natural Resources (CNR) acquired ALAMCO, and continues to operate a large part of the field. The reservoir is highly fractured as well as folded and faulted. Figure 3 is a structure-contour map from Cardwell (1982). Depth to the pay averages between 7,600 and 7,800 feet. Many of the wells in this field probably have estimated ultimate recoveries of a Bcf of gas. Figure 4 is a typical gamma ray/density log from a well in the northeast part of the field. This well was completed only in the

Huntersville Chert, while many wells in the field are completed in both the Huntersville and the Oriskany.

Just outside the state forest to the north, several wells were drilled in the 1990's by R. E. Fox and Associates. These wells also produce from the Huntersville/Oriskany reservoir. This area has not been given a formal field name, but is informally referred to as the "Stateline" field, due to its proximity to the West Virginia/Pennsylvania border.

North of the state line, the South Summit and North Summit pools in the Summit field also have produced from the Huntersville/Oriskany. The North Summit pool, discovered in 1937 (Flaherty, 1996) was converted to gas storage in 1991. Approximately 22 Bcf of gas was produced from the field (Harper, 1987). Depth to the pay averages between 6,713 and 6,910 feet in the 21 productive wells in the field (Flaherty, 1996). The North Summit pool is located on the crest of the Summit dome. As with the South Burns Chapel field, it contains numerous thrust faults (Figures 5 and 6).

References Cited

Cardwell, D. H., 1982, Oriskany and Huntersville Gas Fields of West Virginia: West Virginia Geological and Economic Survey, Mineral Resources Series MRS-5-A, 180 p. and 1:250,000 scale mao, 2 sheets.

Flaherty, K. J., 1996, Play Dho: Fractured Middle Devonian Huntersville Chert and Lower Devonian Oriskany Sandstone: *in* Roen, J. B., and B. J. Walker, editors, The Atlas of Major Appalachian West Virginia Geological and Economic Survey, Publication V-25, p. 103-108.

Harper, J. A., 1987, Oil and gas developments in Pennsylvania in 1986: Pennsylvania Bureau of Topographic and Geologic Survey, Fourth Series, Progress Report PR 200, 93 p.

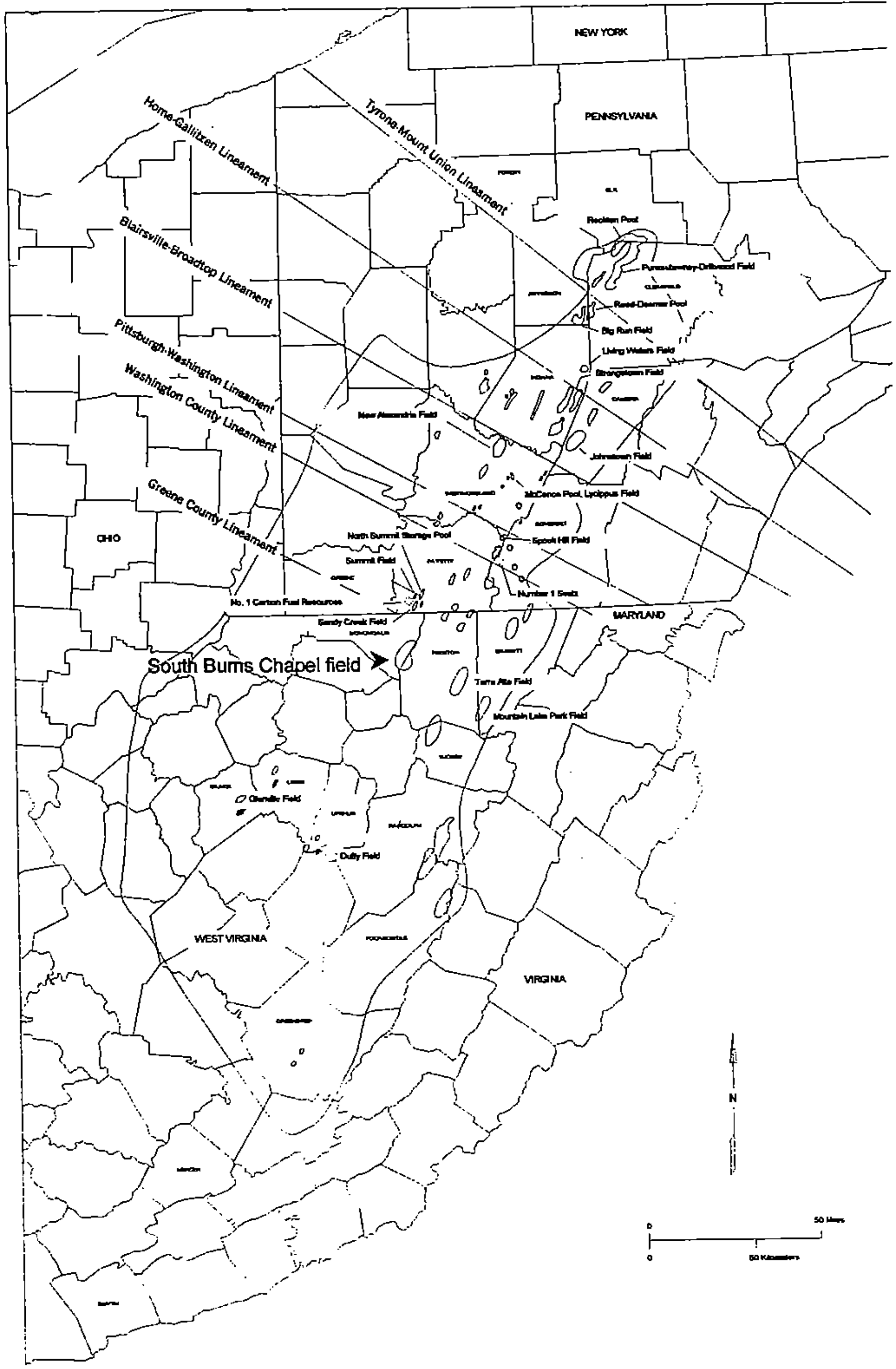


Figure 1. Location of selected Huntersville Chert/Oriskany Sandstone fields and pools, and lineaments. From Flaherty, 1996.

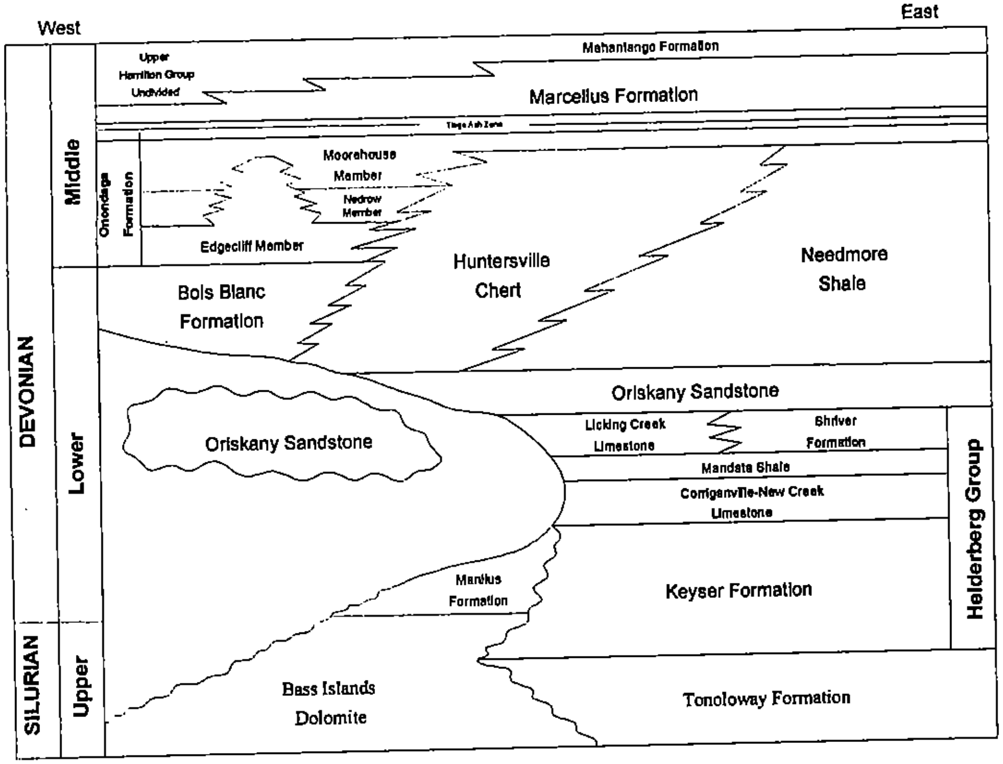
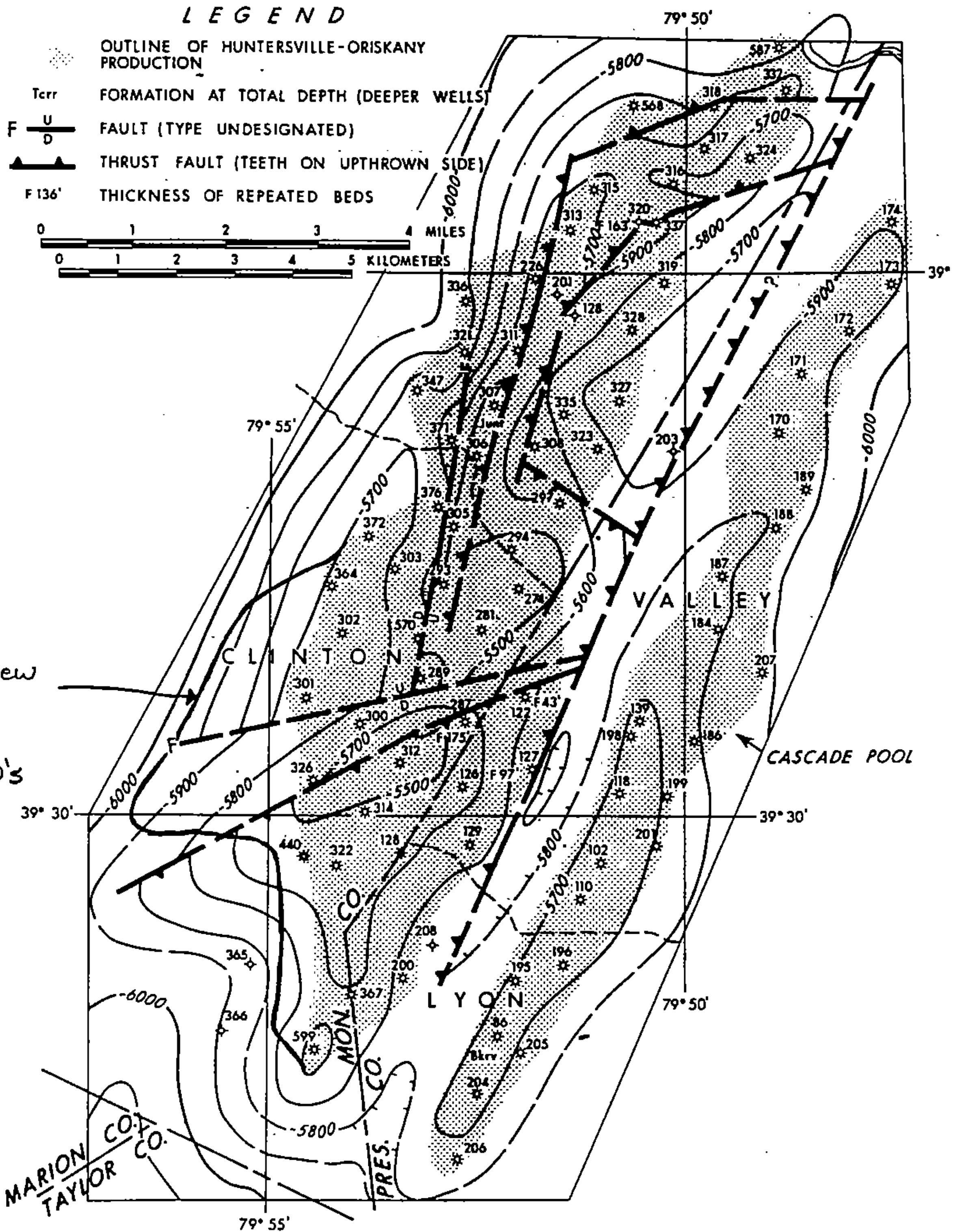


Figure 2. Generalized stratigraphic correlation chart, from Flaherty, 1996.



area of new drilling during the 1990's

FIGURE 22

SOUTH BURNS CHAPEL FIELD

DATUM : TOP ONONDAGA OR EQUIVALENT

CONTOUR INTERVAL : 100 FEET

DUDLEY H. CARDWELL
AS OF SEPTEMBER 1981

Figure 3, from Cardwell, 1982.

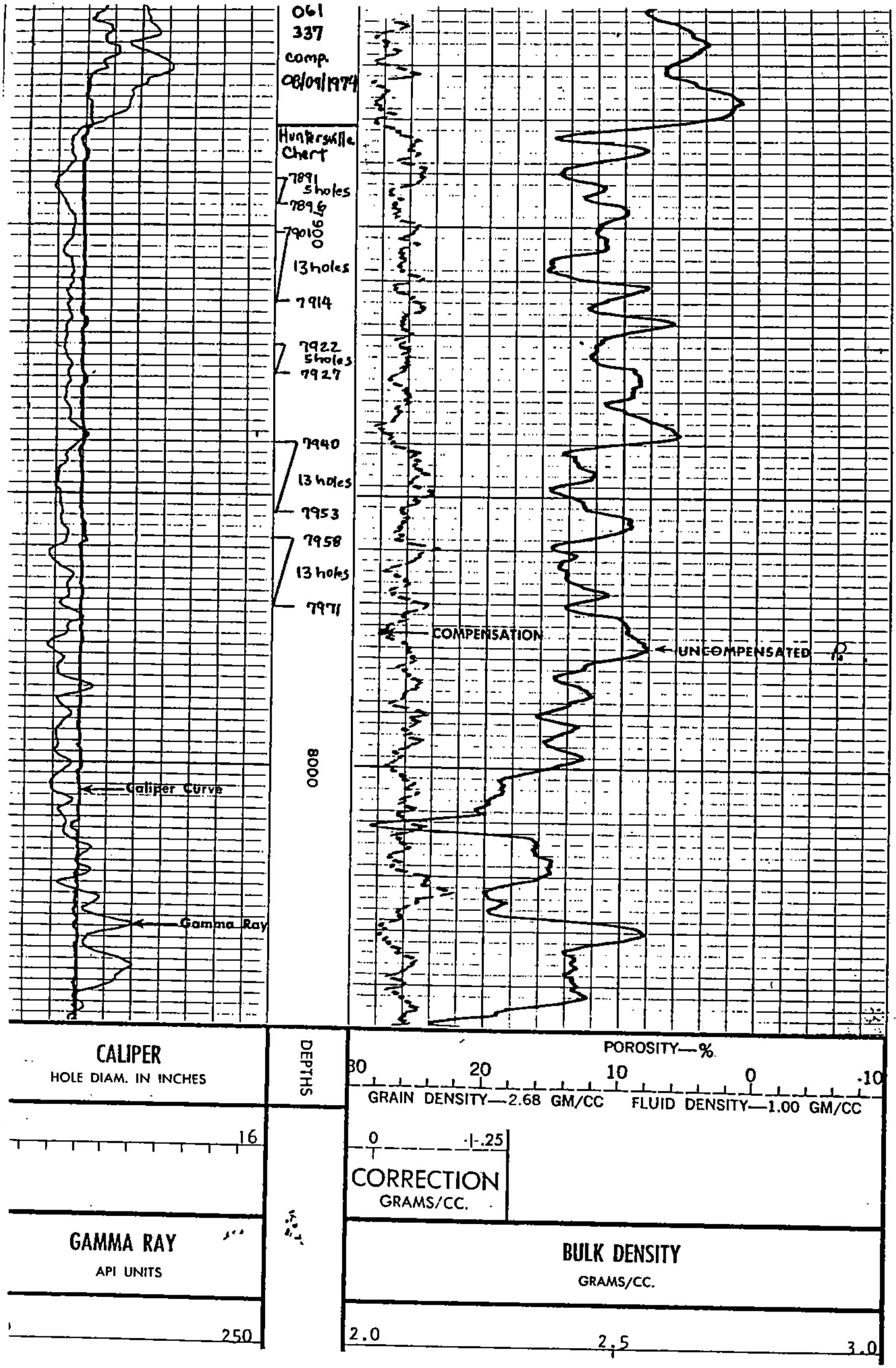


Figure 4. Typical gamma ray/density log from a well in South Burns Chapel field. The well, Monongalia County permit 337, is located in the northeastern part of the field. Perforated zones are indicated.

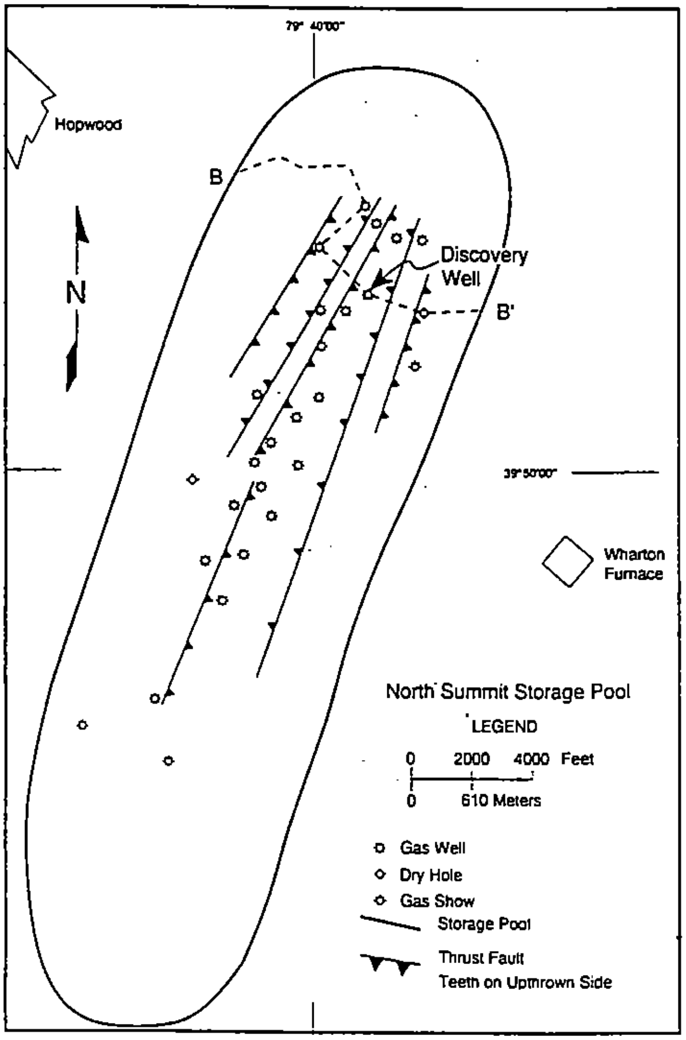


Figure 5. Map of North Summit storage pool, from Flaherty (1996). Location of seismic line B-B' (Figure 6) is shown.

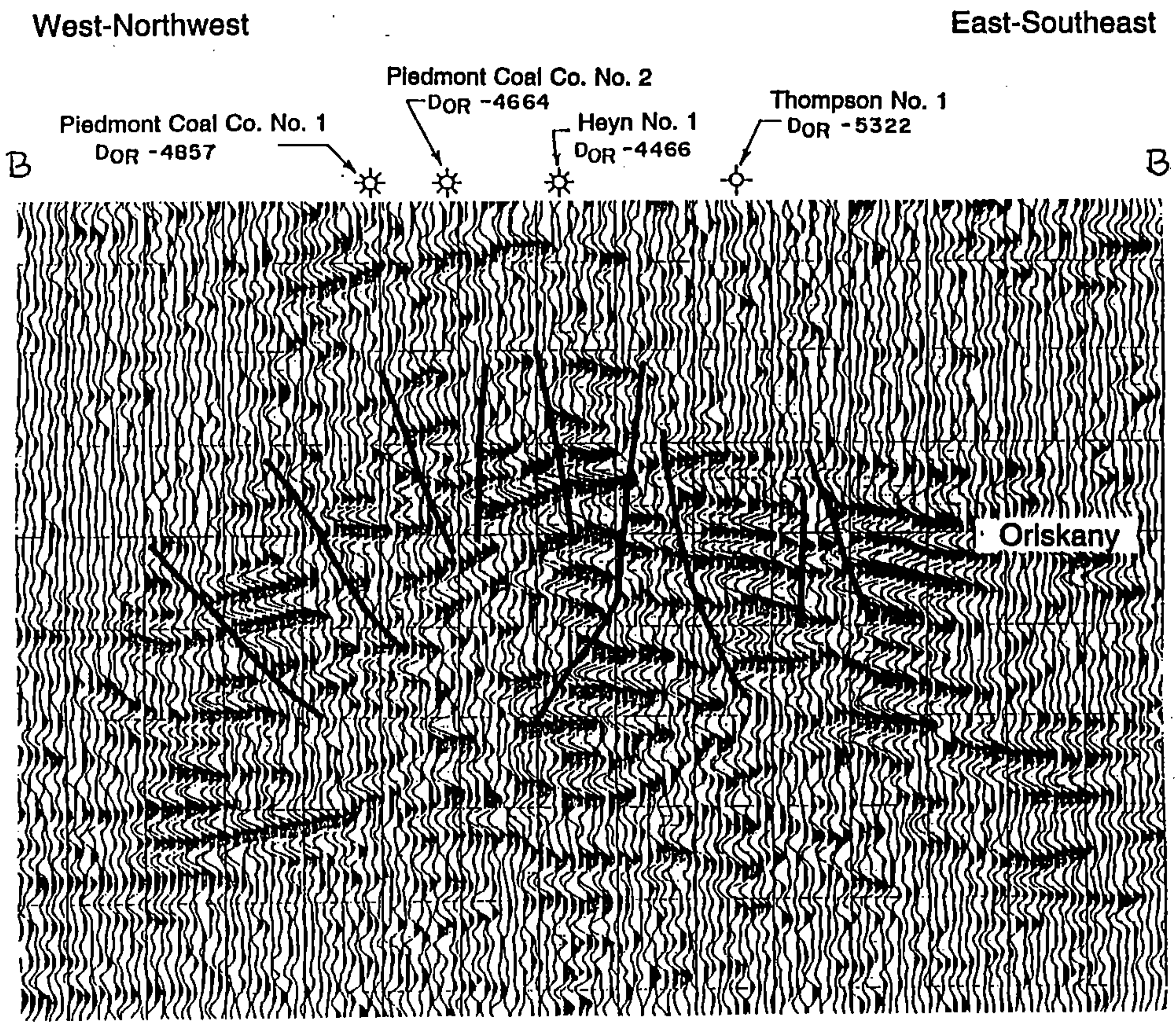


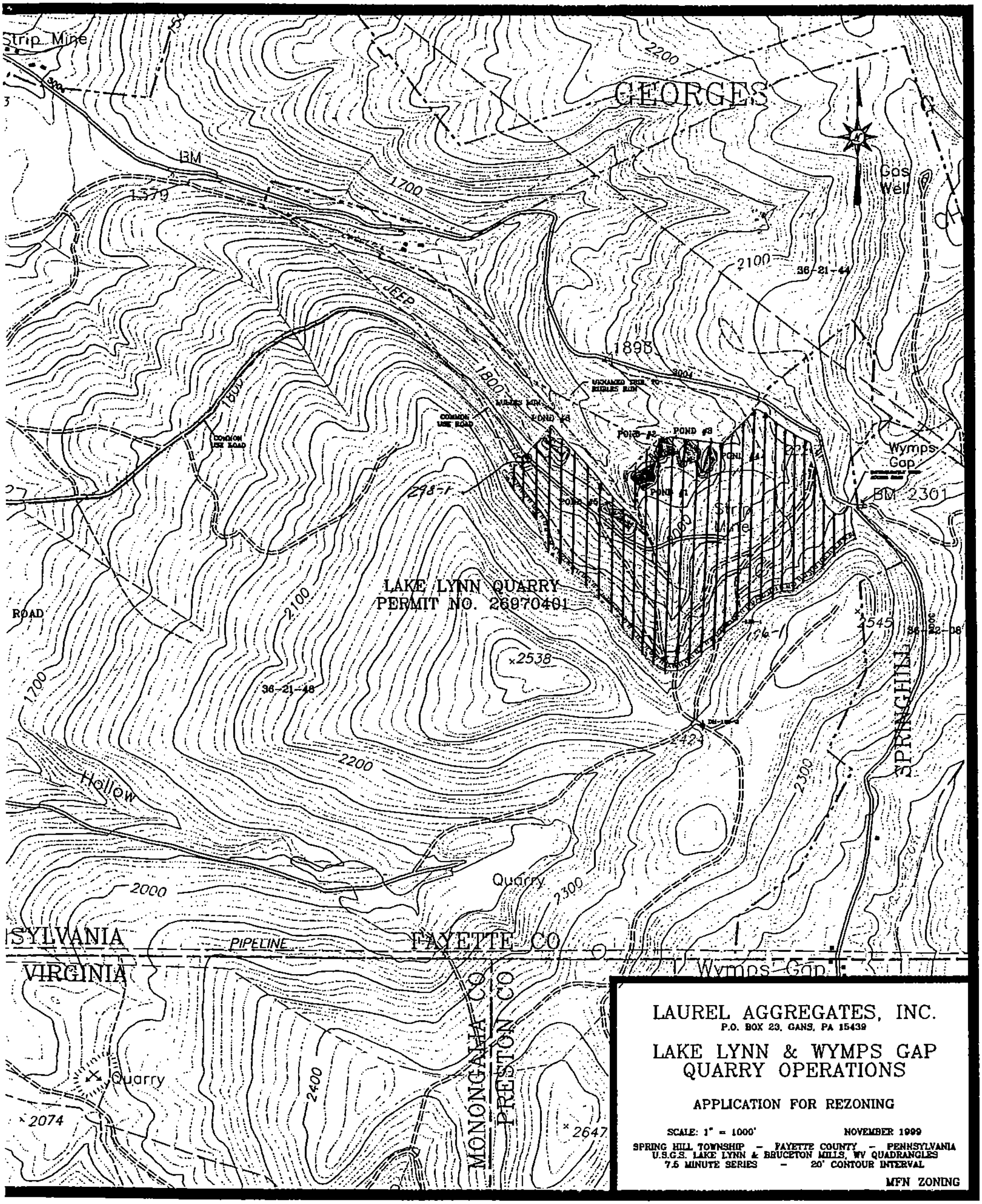
Figure 6. Seismic line B-B' across the North Summit storage field. Location of line is shown in Figure 5. Line and interpretation courtesy of R. Beardsley and R. Campbell,

STOP 6

Our sixth stop is at an old limestone quarry on Laurel Ridge (Chestnut Ridge), in Fayette County, Pennsylvania. We are stopping here for another fossil collecting opportunity. See Figure 1A for Stop 6, for a location map. This quarry exposes the Wymps Gap limestone in its upper section (see Figures 1B and 2), and it exposes the Loyalhanna limestone in its lower section (Figure 3). The Mississippian upper Greenbrier limestone group of West Virginia is the stratigraphic equivalent of the Loyalhanna and Wymps Gap limestones plus intervening shale in southwestern Pennsylvania (Figure 3). Dr. Dick Smosna, the carbonate sedimentology geology professor at West Virginia University, will lecture on the lithology, correlations, and sedimentary setting of these limestones here.

At this site the old Wymps Gap quarry was mined by Martin Marietta Aggregates for limestone for road aggregate; however, the favored Loyalhanna limestone became uneconomical to mine underneath the Wymps Gap limestone, so this quarry was abandoned in the 1960's. In reclaiming this quarry, the company blasted the upper Wymps Gap limestone, which was unusuable by them for aggregate, down into the quarry pit, partially covering the Loyalhanna. This quarry has been recently permitted for renewed mining by Laurel Aggregates, Inc., who will begin mining in December, 2000. This company will sell the Wymps Gap limestone to area coal fired power plants for scrubbing sulfur from burning coal, to help meet new air sulfur pollution standards. Federal U.S.E.P.A. air pollution legislation is fueling a new boom in limestone mining.

See Figures 4 and 5 for pictures of typical fossil animals found within Mississippian limestones such as the Wymps Gap limestone (from Hoskins, et al., 1983). See how many fossils you can find. Trilobites (Kaskia) are especially prized fossils, but fish teeth and jaws (not pictured) are even rarer but have been found here. Please by very careful not to do dangerous climbing on boulders or steep slopes.



LAUREL AGGREGATES, INC.
P.O. BOX 23, GANS, PA 15439

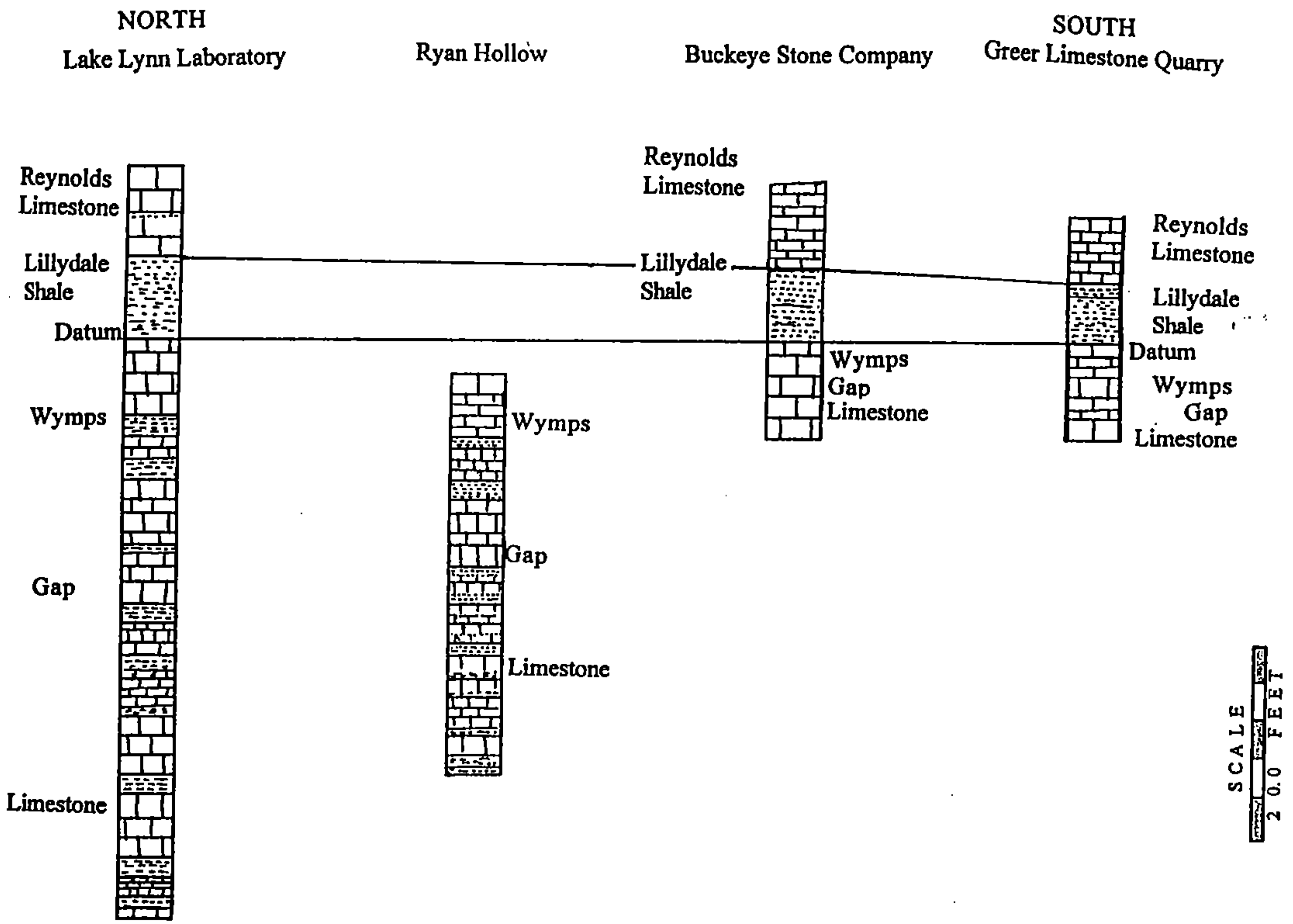
LAKE LYNN & WYMPS GAP
QUARRY OPERATIONS

APPLICATION FOR REZONING

SCALE: 1" = 1000' NOVEMBER 1999
SPRING HILL TOWNSHIP - FAYETTE COUNTY - PENNSYLVANIA
U.S.G.S. LAKE LYNN & BRUCETON MILLS, WV QUADRANGLES
7.5 MINUTE SERIES - 20' CONTOUR INTERVAL

MFN ZONING

STOP 6, FIGURE 1A: from Laurel Aggregates, Inc., 199



Stratigraphic correlation between field localities within the study area. Note that no horizontal scale is implied. Datum used for this correlation is the base of the Lillydale Shale (Refer to Figs. 5, 7, 10 and 13)

STOP 6, FIGURE 2; after Lake (1988).

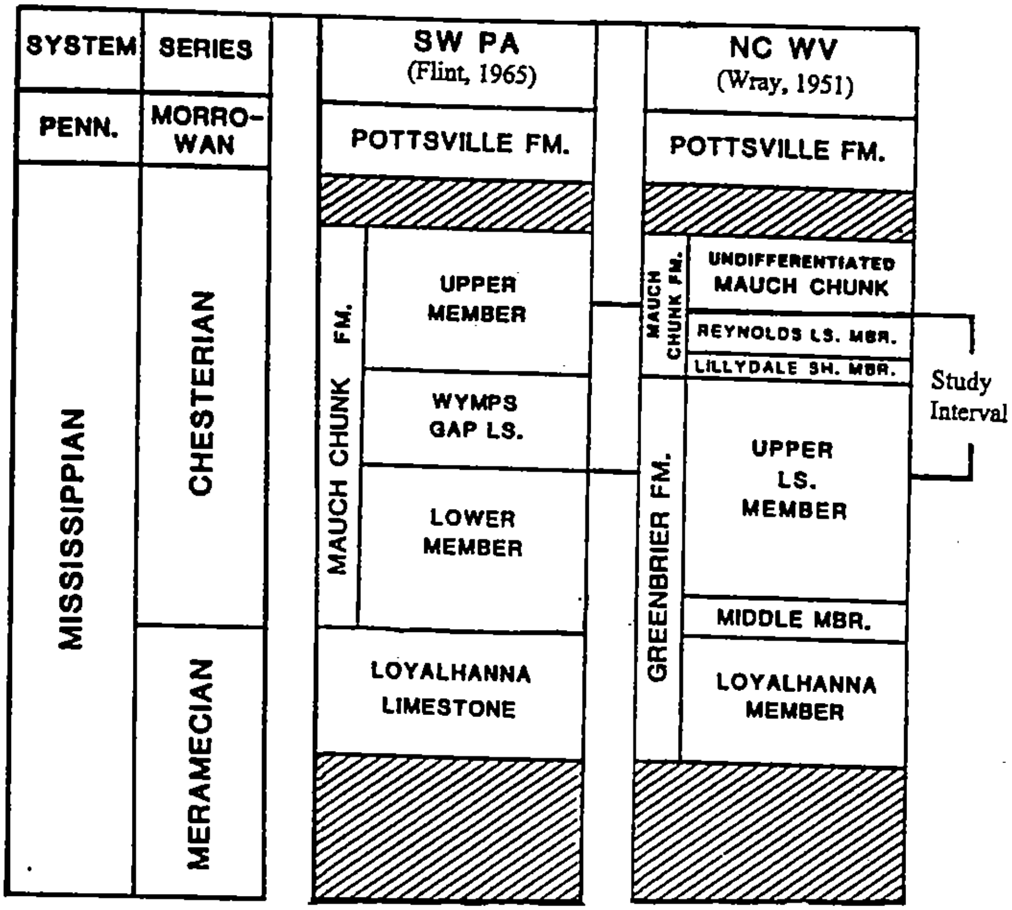
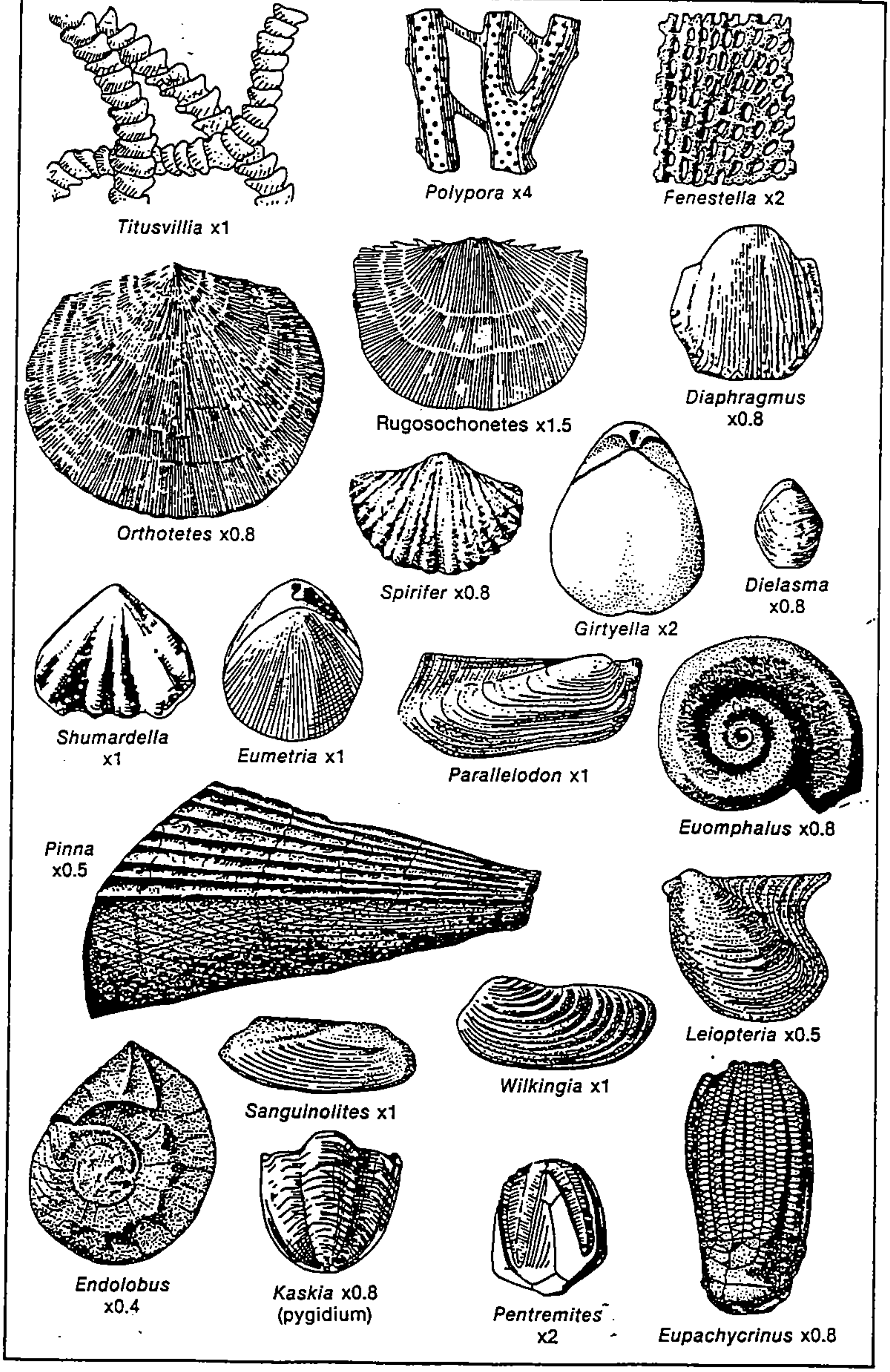


Illustration of differences in stratigraphic nomenclature across the state boundary between West Virginia and Pennsylvania (after Carney, 1987).

STOP 6, FIGURE 3; after Lake (1998).

MISSISSIPPIAN FOSSILS

Plate 12



Titusvillia x1

Polypora x4

Fenestella x2

Rugosochonetes x1.5

Diaphragmus x0.8

Orthotetes x0.8

Spirifer x0.8

Girtyella x2

Dielasma x0.8

Shumardella x1

Eumetria x1

Parallelodon x1

Euomphalus x0.8

Pinna x0.5

Leiopteria x0.5

Wilkingia x1

Sanguinolites x1

Endolobus x0.4

Kaskia x0.8 (pygidium)

Pentremites x2

Eupachycrinus x0.8

STOP 6, FIGURE 4; from Hoskins, et al. (1983).

MISSISSIPPIAN AND PENNSYLVANIAN FOSSILS Plate 13


Septopora x4

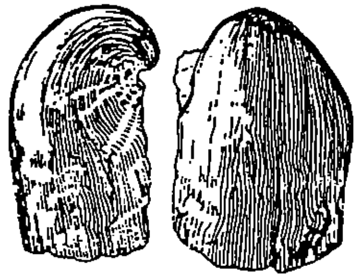

Rhombopora x8


Lingula x3


Rhipidomella x0.8


side top

Dictyoclostus x0.5


side top

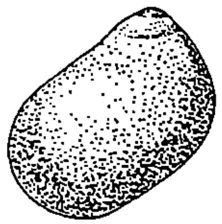
Linoproductus x0.5

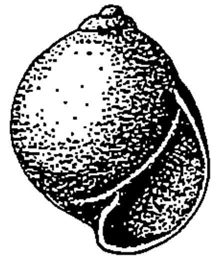

top side

Composita x0.5

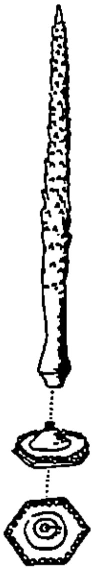

front back side

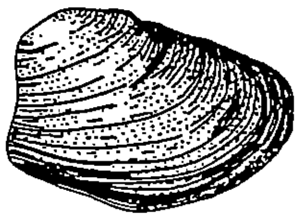
Bellerophon x1


Naticopsis x1


Strobeus x1


crinoid stem
x2


Echinoid spines
and plates
x1.5


Nuculopsis
x2.5


Phestia x0.8

STOP 6, FIGURE5; From Hoskins, et al. (1983).

REFERENCES

diPretoro, R.S., and Rauch, H.W., 1987, Premining Prediction of Acid Drainage Potential for Surface Coal Mines in Northern West Virginia; in Proceedings of the 1987 National Symposium on Mining, Hydrology, Sedimentology, and Reclamation; University of Kentucky, Lexington, Kentucky, pp. 395-404.

Donaldson, Alan, 1994, WVU Department of Geology and Geography - Geology 2 Field Trip Guide Book; West Virginia University, 17 p.

Fedorko, Nick III, 1998, Investigation of a Paleocatena across a Late Pennsylvanian Landscape Comprised of Organic and Mineral Paleosols; M.S. Geology Thesis, West Virginia University, 237 p.

Gray, T.A., Moran, T.C., Broschart, D.W., and Smith, G.A., 1998, Plan for Injection of Coal Combustion Byproducts into the Omega Mine for the Reduction of Acid Mine Drainage; in Proceedings of the Nineteenth Annual West Virginia Surface Mine Drainage Tesk Force Symposium; sponsored by the West Virginia Surface Mine Drainage Task Force and West Virginia Mining and Reclamation Association, 9 p.

Hoskins, D.M., Inners, J.D., and Harper, J.A., 1983, Fossil Collecting in Pennsylvania; General Geology Report 40, Pennsylvania Geological Survey, third edition, 208+ p.

Lake, Andrew M., 1998, Marine Paleoecology of Upper Mississippian Strata in Northern West Virginia and Southwestern Pennsylvania; M.S. Geology Thesis, West Virginia University, 95 p.